**WORKSTUDY AND METHODS ENGINEERING**

**IE 223L**

**LAB MANUAL**



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| Prepared By: |  |
| Guided By: |  |
| Checked By: |  |
| Reviewed By: |  |

**School of Engineering**

**Department of Industrial Engineering**

**University of Management and Technology, Lahore**

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|  |  | **IE-223L - Workstudy and Methods Engineering (Lab)** | | | | | | | | | | | | |
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| **IE-2231** | **Workstudy and Methods Engineering (Lab)** | **Title** | **PLO 1**Engg. Knowledge | **PLO 2**Problem Analysis | **PLO 3**Solution Design | **PLO 4**Investigation | **PLO 5**Mod. Tool Usage | **PLO 6**Engr. & Society | **PLO 7**Env. &Sust. | **PLO 8**Ethics | **PLO 9** Team Work | **PLO 10**Communication | **PLO 11**Proj. Management | **PLO 12**Lifelong Learning |
| **Perform** standardized experimental procedure to take measurementsaccurately **(P 5)** | 🗸 |  |  |  |  |  |  |  |  |  |  |  |
| **Comply** with instructions to perform experiments and respond to questions.  **(C 6)** |  |  |  | 🗸 |  |  |  |  |  |  |  |  |
| **CLO-3: Express** experimental findings in informal or formal laboratory reports using an appropriate technical writing style. (**A3)** |  |  |  |  |  |  |  | 🗸 |  |  |  |  |

**Grading Marking Criteria**

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| --- | --- |
| Lab Assessment | 50% |
| Viva | 25% |
| Final Performance | 25% |

**IE 223L: Course Learning Outcomes (CLOs):**

At the end of the course students should be able to:

* **CLO-1: Perform** standardized experimental procedure to take measurementsaccurately **(P 5)**
* **CLO2: Comply** with instructions to perform experiments and respond to questions.

**(C 6)**

* **CLO-3: Express** experimental findings in informal or formal laboratory reports using an appropriate technical writing style. (A3, CLO3)

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**Experiment # 1**

**Differentiate between time, motion and method study through day to day activities.**

**Literature Review**

**Work Study**

* First technique applied for increasing productivity
* Considered as a valuable tool in increasing productivity

Work study is a generic term for the techniques of method study and work measurement. These techniques are used in examination of human work in all its contexts. They lead systematically to the investigation of all the factors which affect the efficiency and economy at the work place in order to affect improvement.

**Method Study**

Method study is the technique of systematic recording and critical examination of existing and proposed ways of doing work and developing an easier and economical method.

**Objectives**

1. Improvement of manufacturing processes and procedures.
2. Improvement of working conditions.
3. Improvement of plant layout and work place layout.
4. Reducing the human effort and fatigue.
5. Reducing material handling.
6. Improvement of plant and equipment design.
7. Standardization of method.
8. Improvement in safety standard.

**Basic Procedure for Method Study**

The basic procedure for conducting method study is as follows:

1. Select the work to be used.
2. Record all facts about the method by direct observation.
3. Examine the most efficient and economic method.
4. Install the new mwthod.
5. Maintain the new method by regular checking.

**Procedure**

1. Select the work to be studied from daily activities.
2. Apply method study procedure to it.
3. Do the time study where needed.
4. Maintain a record and follow written activities.

Comments and Suggestions

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**Experiment # 2**

**Stop-Watch time study of simple assembly operations through scientific method principle of Taylor**

**Apparatus**

Ball Point, Stop Watch, Table and Chair

**Principle**

There is one best way to do a job and that this way should be discovered and put into operation.

**Literature Review**

**Time Study**

A work measurement technique consisiting of careful time measurement of the task with a time measuring instrument, adjusted for any observed variance from normal effort or pace and to allow adequate time for such items as foreign elements, unavoidable or machine delays, rest to overcome fatigue, and personal needs.

Time study is a direct and continuous observation of a task, using a time keeping device (e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera) to record the time taken to accomplish a task and it is often used when:

* There are repetitive work cycles of short to long duration,
* Wide variety of dissimilar work is performed, or
* Process control elements constitute a part of the cycle.

**Standards**

Standards are the end result of time study or work measurement that is done through stopwatch or any other time measuring technique.

**Standard time**

In industrial engineering, the standard time is the time required by an average skilled operator, working at a normal pace, to perform a specified task using a prescribed method. It includes appropriate allowances to allow the person to recover from fatigue and, where necessary, an additional allowance to cover contingent elements which may occur but have not been observed.

The standard time can be determined using the following techniques:

* Time study,
* Predetermined motion time system aka PMTS or PTS,
* Standard data system,
* Work sampling.

The Standard Time is the product of three factors:

* Observed time: The time measured to complete the task.
* Performance rating factor: the pace the person is working at. 90% is working slower than normal, 110% is working faster than normal, 100% is normal. This factor is calculated by an experienced worker who is trained to observe and determine the rating.
* The standard time can then be calculated by using Personal, Fatigue, and Delay (PFD) allowance.

Standard Time = (Observed Time)(Rating Factor)(1+PFD Allowance)

**Methods engineering is** the analysis and design of work methods and systems, including the tooling, equipment, technologies, workplace layout, plant layout, and the work environment. Methods engineering is the systematic close scrutiny of all direct and indirect operations to find improvements that make work easier to perform, in terms of worker health and safety, and also allow work to be done in less time with less investment per unit (i.g., greater profitability).

Other names for Methods Engineering:

* Work Study
* Work Simplification
* Methods Study
* Process Re-Engineering
* Business Process Re-Engineering

Methods Engineers use a systematic procedure to develop a work center, produce a product, or provide a service.

**Procedure**

1. Assemble the ball point in random sequence
2. Note the time for assembling and record as the random method time
3. Assemble the ball point according to prescribe method
4. Note the time for standard method
5. Place in directed orientation
6. Hold tube in left hand and insert nib with right hand
7. Insert the push cork and at the end, place the cap
8. Note the time for assembling and record as the standard method time

**Obervations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr #** | **Operator** | **Time Noted for Random method** | **Time for standard method** | **Difference** |
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**Comments**

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**Experiment # 03**

**The use of principles of motion economy in assembly of pins in the pin board**

**Principle**

There is one best way to do a job and that this way should be discovered and put into operation. (Taylor’ s scientific management principle)

**Literature Review**

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* Business Process Re-Engineering

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**Observations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr #** | **Operator** | **Time by Conventional method (tc)** | **Time by improved method(ti)** | **%age saving in time ((tc- ti/ tc))\*100** |
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**Comments**

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**Experiment # 4**

To draw the man m/c of the part produced.

**Apparatus**

Work piece, stop watch, lathe machine, shaper machine.

**Literature Review**

**Man Machine Chart**

A man-machine chart is a chart in which the activities of more than one worker or machine are recorded. Activities are recorded on a common time scale to show the inter-relationship. It is also known as **Multiple Activity Chart**. Although the process chart and the flow diagram give a picture of the various steps in the process, it is often desirable to have a breakdown of the process or of a series of operations plotted against a time scale. Such a picture is called **An Activity Chart.** The operator and the machine work intermittently on some types of work. That is, the machine is idle while the operator loads it or while he or she removes the finished work from it and the worker is idle while the machine is in operation. It is desirable to eliminate idle time for the worker, but it is equally important that the machine be kept operating at near capacity as possible.

The first step in eliminating unnecessary waiting time for the operator abd for the machine is to record exactly when each works and what each does. Such a record is called **Man & Machine Chart.** It is used when a worker operates a number of machines at a time. It is also used when a number of workers jointly do a job. Activities of workers or machinesare recorded in a separate vertical columns (bars) with a horizontal time scale. The chart shows the idle time of the worker or machine during the process. By carefully analyzing the chart, we can rearrange the activities. Work load is evenly distributed among the workers or machines by this the idle time of worker or machine is reduced. Multiple Activity Chart is very useful in planning team work in production and maintenance. Using the chart we can find out the correct number of machines that a worker can operate at a time. We can also find out the exact number of workers needed to do a job jointly.

To record the time, ordinary wrist watch or stopwatch is used. High accuracy is not needed. Man-machine chart is a type of Multiple activity chart. Here, the activities of a number of machines are recorded.

An example of Man-Machine Chart is shown in figure 1. Here one operator two semi-automatic machines simultaneously. The activities of the operator are recorded in a separate vertical column. The activities of the two machines are recorded in two separate vertical columns. The different activities like loading, machining and unloading are represented by different symbols. Blank space shows the idle time.

Many operations consist of three main steps:

1. GET READY, such as putting material in the machine,
2. DO (doing the work), such as drilling a hole; and
3. Waiting for an operation to be completed or “idle”.

The Man-Machine Chart, or Simochart, is a planning industrial graphically defining resources’ activity (robots, operators etc ) at repetitive tasks. It is typically used to plan the activity of resources in large and medium series. Very often a clearer picture of the relationship of the operators’ working time and the machine time can be obtained by showing the information graphically to scale.

**Cycle Time**

Each resource continually performs the same tasks. When the last task is completed, the resource runs again the first task. This estate is called **Cycle.** A diagram is constituted of tangled cycles. The duration of the longest cycle is called **Time of Cycle.** It is usually the time needed to produce or assemble a piece.

**Operator Cycle Time**

Time total time required for a worker to complete one cycle of an operation

**Machine Cycle Time**

Total time for a machine to finish one complete cycle is Cycle Time. It includes loading n unloading.

**Procedure**

1. Make the machine ready for the job to be loaded.
2. Note the set up time before starting the job.
3. Note the time for all operations, i.e. turning and facing, shaping and sizing
4. Note the time for unloading the job from the machine.
5. Mark the state of machine and man as idle or busy during the operation

**Observations & Calculations**

1. Get Ready
2. Do
3. Put away or clean up

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr #** | **Operator** | **Man** | | **Machine** | |
| **Time** | **Remarks** | **Time** | **Remarks** |
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**Summary**

|  |  |  |
| --- | --- | --- |
|  | **Man** | **Machine** |
| **Idle Time** |  |  |
| **Working Time** |  |  |
| **Total Cycle Time** |  |  |
| **Utilization in %** |  |  |

**Comments**

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**Experiment #05**

**To draw the operation process chart of the part produced**

**Apparatus**

Lathe M/C

Raw Material

Stop watch

**Literature Review**

**Process Chart**

The process of production of a piece of work should be analyzed thoroughly before undertaking a detailed investigation of a specific operation in the process. Such an over-all study will ordinarily include an analysis of each step in the manufacturing process, thus pointing out the advantages and the flaws of the route adapted for the production. One such method of examination the process is the process chart. The process chart is a device for recording aprocess in a compact manner, as a means of better understanding it and improving it. The chart represents graphically the separate steps or events that occur during the performance of a piece of work or doing a series of actions. The cart usually begins with the raw material entering the factory and follows it through every step, such as transportation to storage, inspection machining operations, assembly, until it becomes either a finished unit itself or a part of a sub assembly. The process chart might have, record the process through only one or a few departments. A process chart gives an overall picture of an event by recording the main operations and inspections in sequence. Only the principal operations carried out and the inspections made to ensure effectiveness are recorded, irrespective of who does them and where they are performed. A brief note of the nature of each operation or inspection is made beside the symbol, and the time allowed for it is also added. It is a graphic representation of the sequence of all operations and inspections taking place in a process. It is also known as outline process chart. It gives a bird's eye view of the overall activities Entry points of all material are noted in the chart

**Process chart symbols**

The recording of the facts about the job in a procesS chart is done by using standard symbols

Using of symbols in recording the activities is much easier than writing down the facts about

holidays are very convenient and widely understood type of short hand. They save a lot

of writing and indicate clearly what is happening

**Operation**

Indicates the main steps in a process, method or procedure. Usually the part, material or

product is modified or changed during the operation.

**Inspection**

Indicates an inspection for quality and/or check for quantity

**Transport**

Indicates the movement of workers, materials or equipment from place to place.

**Temporary storage or delay**

Indicates a delay in the sequence of events; for example, working waiting between consecutive

operations, or any object laid aside temporarily without record until required

**Permanent storage**

Indicates a controlled storage in which material is received into or issued from a store under

some form of authorization

**Combined activities**

The circle within the square represents a combined operation and inspection.

**Procedure**

1. Make the machine ready for the job to be loaded

2. Note the Setup time before starting the job

3. Note the time for all operations

4. Note the time for unloading the job from the machine.

5. Note the operations simultaneously.

**Mark the state of**

1. Operation
2. Inspection
3. Transport
4. Temporary Storage
5. Permanent Storage

**Observations**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr #** | **Time** | **Symbol** | **Description** |
|  |  |  |  |
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**Comments**

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**Experiment #06**

**To draw the flow process chart of the part produced**

**Apparatus**

Lathe M/C

Raw Material

**Literature Review**

**Flow Process Chart**

A flow process chart is a graphical representation of the sequence of all the activities (operation, inspection, transport, delay and storage) taking place in a process. Process chart symbols are used here to represent the activities

There are three types of flow process charts. They are:

**1. Man type flow process chart**

This flow process chart records what the worker does

**2. Material type flow process chart**

This flow process chart records how the material is handled or treated

**3. Equipment type flow process chart**

This flow process chart records how the equipment or machine is used.

The activities of a stenographer in preparation of a letter are recorded in the operator type flow

process chart shown in figure

1. The details must be obtained by direct observation charts must not be based on memory

2 All the facts must be correctly recorded.

3. No assumptions should be made.

4. Make it easy for future reference.

All charts must have the following details:

(a) Name of the product, material or equipment that is observed.

(b) Starting point and ending point

(c) The location where the activities take place

(d) The chart reference number, sheet number and number of total sheets.

(e) Key to the symbols used must be stated

**Two-Handed Process Chart (or) Right Hand, Left Hand Chart**

* It is the process chart in which the activities of two hands of the operator are recorded
* It shows whether the two hands of the operator are idle or moving in relation to one another, in a timescale.
* It is generally used for repetitive operations

**Operation:**

Represents the activities grasp, position, use, release etc.of tool, component or material

**Transport:**

Represents the movement of the hand or limb to or from the work or a tool or material

**Delay:**

Refers to the time when the hand or limb is idle

**Storage (Hold**):

The term hold is used here instead of storage. This refers to the time when the work is held by

Hand. The activity inspection by hand is considered as an operation. Hence, the symbol for inspection is not used in this chart.

Two-handed process chart can be used for assembly, machining and clerical jobs.

General guidelines for preparing the chart

1. Provide all information about the job in the chart.

2. Study the operation cycle a few times before starting to record

3. Record one hand at a time.

4. First record the activities of the hand which starts the work first

5. Do not combine the different activities like operations, transport etc.

**Example**

Example of a two-handed process chart is shown in figure 2 Here the assembly of a nut and washer over a bolt is recorded. The work place layout is shown in the right hand corner. The activities of left hand are recorded at left half of the chart. The activities of the right hand are recorded at the right hall of the chart The horizontal lines represent the time scale. Activities of left hand and right hand shown in the same line occur at the same movement. Summary of the number of each activity can be tabulated at the bottom of the chart. The chart is first drawn for the existing method This chart is analyzed and if it is found that one hand is over loaded than the other modification are done in the layout of the workplace or in the sequence of activities. Then a new.chart is made for the proposed cycle

**Procedure**

1. Measure the time and distance of each activity

2. Plot the work place layout in the right hand corner

3. Record the activities of left hand at left half of the chart

4. Record the activities of the right hand are recorded at the right half of the chart

5. The horizontal lines represent the time scale.

6. Show activities of left hand and right hand that occur at the same moment in the same line.

**Observations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr #** | **Activities** | **Distance** | **Time** | **Symbols** | **Remarks** |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

**Comments**

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**Experiment #07**

**To study fundamental hand motion and development of right hand process chart with the help of camera**

**Apparatus**

Pen

Paper

Camera with accessories

Stopwatch

**Literature Review**

**Fundamental Hand Motions**

Most work is done with two hands and all manual work consists of a relatively few fundamental motions that are performed over and over again. Frank G.Gilbreth, in his early work in motion study, developed certain subdivisions or events which he thought common to all kinds of manual work. He coined the work therblig in order to have a short word with which to refer to any of these 17 elementary subdivisions of cycle of motions. The experienced analyst has no difficulty in using these therbligs in industrial applications.

Although the word therblig is familiar to industrial engineers, the term motion or hand motion is preferred when discussing the subject of micromotion study with factory and office personnel.

**1. Search** : that part of the cycle during which the eyes or the hands are hunting or groping for the object. "sh begins when the eyes or hands begin to hunt for the object, and ends when the object has been found.

**2. Select**: the choice of one object from among several. in many cases it is difficult if not impossible to determine where the boundaries lie between search and select. For this reason itis often the practice to combine them, referring to both as the one therblig select Then the broader definition of select refers to the hunting and locating of one object from among veral. "St begins when the eyes or hands begin to hunt for the object and ends when desired object has been located

**3. Grasp**: taking hold of an object, closing the fingers around it preparatory to picking holding it or manipulating it "G" begins when the hand or fingers first make contact with the object, and ends when the hand has obtained control of it

**4. Transport empty (TE)**: moving the empty hand in reaching for an object it is assumed that

the hand moves without resistance toward or away from the object. "TE begins when the hand

begins to move without load or resistance, and ends when the hand stops moving

**5.Transport loaded (TL)**: moving an object from one place to another The object may be carried in the hands or fingers, or it may be moved from one place to another by sliding, dragging, or pushing it along. Transport loaded also refers to moving the empty hand against resistance TL begins when the hand begins to move an object or encounter resistance, and ends when the hand stops moving

**6. Hold (H):** retention of an object after it has been grasped, no movement of the object taking

place. "H" begins when the movement of the object stops, and ends with the start of the next

therblig

**7. Release load (RL):** letting go of the object. "RL begins when the object starts to leave the

hand, and ends when the object has been completely separated from the hand or fingers.

**8. Position (P):** turning or locating an object in such a way that it will be properly oriented to fit

into the location for which it is intended. It is possible to position an object during the motion

transport loaded. "P" begins when the hand begins to turn or locate the object, and ends when

the object has been placed in the desired position or location

**9.Preposition (PP):** locating object an in predetermined place, or locating it in the correct position for some subsequent motion at "pp" is the same as position except that the object is allocated in the approximate position that will be needed later.

**10 Inspect ():** examining an object to determine whether or not it complies with standard size, shape, color, or other qualities previously determined. The inspection may employ sight hearing, touch, odor, or taste. Inspect is predominantly a mental reaction and may occur simultaneously with other therbligs "I "begin when the eyes or other parts of the body begin to nine the object and ends when the examination has been completed

**11.Assemble (A):** placing one object into or on another object with which it as an integral part. A begins as the hand starts to move the part into its place in the assembly, and ends when the hand has completed the assembly

**12. Disassemble (DA):** separating one object from another object of which it is an integral part. "DA"begins when the hand starts to remove one part from the assembly and ends when the hand has separated the part completely from the remainder of the assembly

**13. Use (U):** manipulating a tool, device, or piece of apparatus for the purpose for which it was intended. "U begins when the hand starts to manipulate the tool or device, and ends when the hand ceases the application.

**14. Unavoidable delay (UD):** a delay beyond the control of the operator UD" may result from either of the following causes:

(a) a failure or interruption in the process

(b) an arrangement of the operation that prevents one part of the body from working while other body members are busy. "UD"begins when the hand stops its activity, and ends when activity is resumed

**15. Avoidable delay (AD):** any delay of the operator for which he or she responsible and over which he or she has control. It refers to delays, which the operator may avoid if desired. "AD" begins when the prescribed sequence of interrupted, and ends when the standard work method is resumed

**16. Plan (On):** a mental reaction, which precedes the physical movement that is. deciding how to proceed with the job. "Pn" begins at the point where the operator followed has been determined Mansio work out the next step of the operation, and ends when the procedure to be

**17. Rest for overcoming fatigue (R):** a fatigue or delay factor or allowance provided permit the worker to recover from the fatigue incurred by the work. R" begins when the operator stops workhg, and ends when work is resumed.

**TIME MEASURING UNITS**

**1 TMU 0.00001 hour**

**TMU 0.0006 min**

**TMU = 0,036 sec**

**1 hour= 100,000 TMU**

**1 min=1667 TMU**

**1 sec = 27.8 TMU**

**Procedure**

Note the time of each activity

2 Therbligs should be carefully separated from each other.

3. Write the Name of motion required for each activity

4. Note the symbol for it

5. Note the Description for each activity

**Observations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr #** | **Name of Motion** | **Symbol** | **Description** | **Time** | **TMU** |
| **1** |  | **TE** |  |  |  |
| **2** |  | **G** |  |  |  |
| **3** |  | **TL** |  |  |  |
| **4** |  | **P** |  |  |  |
| **5** |  | **U** |  |  |  |
| **6** |  | **TL** |  |  |  |
| **7** |  | **PP** |  |  |  |
| **8** |  | **RL** |  |  |  |
| **9** |  | **TE** |  |  |  |

**Comments**

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**Experiment # 08**

**To draw the flow chart of the part produced.**

**Flow Chart**

**Flow Diagram**

In any production shop repair shop or any other department there are movements of men and material from one place to another Process charts indicate the sequence of activities They do not show the frequent movements of men and material these movements are minimized, a lot of savings can be achieved in casa effort. In the path of movement of material is not frequent and simple, flow diagram is used for recording the movement. A flow diagram is a diagram which is drawn to scale. The relative position of machineries. gangways material handling equipment etc s drawn first. Then the path followed by men or material is marked on the diagram Different movements can be marked in different colours.Proces symbols are added to the diagram to identify the different activities at different work Centres

**Utilization:**

The flow diagram is used for the following purposes

1. To remove unwanted material movement

2 To remove back tracking

3 To avoid traffic congestion.

4. To improve the plant layout

**Conventions adopted are**

1 Heading and description of the process should be given at the top of the diagram

2 Other information like location, name of the shop, rime of the person drawing the diagram are

also given

3. The path followed by the material is shown by a flow line

4 Direction of movement is shown by small arrows along the flow lines

5.The different activities are represented by the symbols on the flow limes (Same symbols used in flow process chart are used here)

6. If more than one product is to be shown in the diagram different coloured for each path

**Comments**

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**Experiment #09**

**To draw the improved layout of workshop lab through string diagram**

**Apparatus**

Pins

String

Measuring tape

**Literature review**

**String Diagram**

We make use of flow diagram for recording the movement of men or material when the movement is simple and the path is almost fixed. But when the paths are many and are repetitive it may not be possible to record them in a flow diagram. Here a string diagram is used String diagram is a scaled plan of the shop. Location of machines and various facilities are drawn to scale in a drawing sheet Pins are fixed at the various work centres in the drawing sheet. A continuous coloured thread or string is taken round the pins where the material or worker moves during the process. The string diagram is a scale plan or model on which a thread is used to trace and measure the month of workers, material or equipment during a specified sequence of events The string diagram is a special form of flow diagram, in which a string or thread is used to measure distance. It is necessary that the string diagram be drawn correctly to scal The string diagram is started in exactly the same way as all other method studies by recording all the relevant facts from direct observation A string diagram can be used to plot the movements of materials, and, especially when a work study person wants to find out easily just how far the materials travel.

**EXAMINE critically**

* A study of the diagram shows at once that the most frequent movement is the 10 x 10 and 15x 15 rows of bins. Tiles are constantly being withdrawn for glazing

**DEVELOP the new layout**

The first step in developing the new layout is to locate the bins containing the most handled tiles as near as possible to the inspection bench and those containing special feature" tiles as far away as possible. The distances covered were reduced from 520 to 340 meters, a saving of 35 per cent String diagrams are particularly useful to study the movement of workers in circumstances like one man attending several machines, processes involving involvement of the worker from one place to another, etc

**String Diagram:**

The string diagram is a scale plan or model on which at bread is used to trace and measure the pat of worker materials of equipment during a specified sequence of events When there is too much of movement involved then, a flow diagram may become incomprehensible In such cases, string diagram is used The scale layout is fixed to a board and plans, are driven into the board to mark the location of various activities and also at points where the direction wound round the pins following the various activities in sequence. The distance covered can be calculated by measuring the length of the thread used. These diagrams are particularly useful when, considering problems of plant layout' and design Proposed improvements can be effectively demonstrated bold, to management and workers Features like back-tracking, excessive movement and congestion are clearly shown hips to take steps to improve the situation. String Diagram is a scale layout drawing on which, length of a string is used to record the extent as well as the pattern of movement of a worker working within a limited area during a certain period of time. It is a scale diagram on which color threads are wrapped around pins or pegs which are used to indicate the paths taken by either worker or material or equipment when processing is done on material from start to finish String diagram is thus a special form of flow diagram in which a string or thread is used to measure distance because of this it is necessary that the string diagram be drawn correctly to scale whereas the ordinary flow diagram will probably be drawn only approximately to scale with pertinent scale marked on it so that scaling off is necessary Thus, it is a special form of flow diagram in which a string or thread is used for measuring the distance traveled The string diagram is started exactly in the same way as all other method studies: by recording all the relevant facts from direct observation This may be achieved by using a simple movement study sheet" The observation and hence the recording continues until the work study man becomes sure they obtained facts give the true picture of the sam

**When to use it**

* Use it when analyzing a manual or physical process that involves significant physical movement, in order to make movements easier and quicker Movements may be of people, materials or machines
* Use it when designing the layout of a work area, to identify the optimum positioning of machines and furniture

**How to understand it**

The placement of equipment and furniture in work areas is often done randomly and sequentially, rather than with any sense of what positioning will make the work casier. The result is that subsequent work requires much more moving about than is necessary. A part of the

problem is that when designing a work area, it can be difficult to see what movement will be necessary The String Diagram is a simple tool for analyzing and designing work spaces such that movement can be minimized, The basic diagram simply consists of a map of the work area, with the actual movements drawn on top, thus It is common to also indicate type of actions being done at cach point. This is typically done in the same symbol set that is used in the Flow Process Chart. When analyzing the diagram, both the positioning of equipment and the sequencing and detail of actions may be considered. A simple revision of the process may enable the distance moved to be significantly reduced (this may well be preferable to moving heavy equipment around)

**Example**

A metal worker became fed up with walking what seemed to be half-way around the machine room to build a metal box. With help from the works facilitator, he measured the distance be traveled to build one box, using a pinboard and scale map of his workshop area, as below.

**Other examples**

A self-service restaurant team measures the route taken by customers around the food counters and also identifies the most popular meals that they are building They rearrange the counters and food to enable a logical progression for the most common meals. They also include complementary and high-margin food in this line, which helps to increase the profitability of the restaurant A traffic planning department uses a helicopter to spot the routes taken by a sample of vehicles passing through the town, plotting the lines on a street map Common destination and routes are now easily identified (along with short-cuts taken through residential areas As a result, some roads are widened, others are blocked and signs erected. The results much smoother traffic flow maintenance team measures the route taken by engineers making routine checks on key oment throughout the plant, plotting it on a site plan. They are then able to plot much shorter route to each of the same machines.

**Procedure**

1.Identify the process to be analyzed. This will be one which involves a significant amount of movement by people, materials or both

2. Produce a scale map of the work area, not including machines, but including items that cannot easily be moved, such as power points, airlines, etc. This may be available from the site ollice

3. Add all machines, furniture and other equipment to the diagram. If possible, do this in a way that will allow these to be moved, for example by using shaped pieces of card that can be pinned to the work area map from step 2

4.Identify the points in the process where actions take place and mark the positions of these on the map with map pins Where there are different action types, these can be differentiated by marking or pinning down paper action symbols (typically the same as those used in the Flow Process Chart).

5. Tie the end of a piece of string to the pin where the process starts, and then wrap it around cach pin in turn, following the movement around the process, as in the figure below. Tie the string off at the last position (which may be the start point, if the person returns there)

6. Mark the string at the start and finish points, using a pen. Remove the string and measure between the penmarks, using the map scale. This will give the total distance traveled during the process

7 Rearrange the movable items on the map, aiming to reduce the total distance as measured in step 6. It may be appropriate to change what is done during the process at the same time. For example, some operations may be combined or eliminated. Strategies for deciding layouts include: Mobility, Rearrange items and movements around fixed or immovable items, such as heavy machines. Function Put machines or people together that perform the same function. This is useful when varying loads may be shared between machines. Product. Put machines or people together that make the same product. This works well when each machine is used for only one product Repeat steps 4 to 6, to get a new total distance traveled Using the same piece of string will make it easy to see how much shorter this is ok that it is feasible to move equipment as planned in step 7, then do so. Measure the final process in practice to check that improvements are as expected

**Practical variations**

Do a Flow Process Chart first, and then follow up with a String Diagram. This helps clarify the actions in the process, making the String Diagram easier to complete It also results in a more complete analysis. Draw the map and 'string' on a single sheet of paper. This requires fewer resources, and gives a result that can be easily copied, although it is less flexible for redesigning Do multiple plots on the same diagram, for example where one person does the same processin a different way, or where multiple people or items are involved Use colored pins to indicate different action types or different plots done on the same map Use colored string to show different plots. Ifit is significant, add the time taken for each movement Annotate the diagram with pertinent notes to help interpretation, for example by giving notes on what is being done at each point, and why String Diagram: Procedure and Purpose of String Diagram!

String diagram is one of the useful and simplest techniques of method study. It can be defined as on which a thread is used to trace the path or movements of man and materials during a specified sequence of events be stated that string diagram in a special form of flow diagram. As a thread is used to distance, it is necessary that the string diagram should be drawn up to scale. The same measure de necessary in case of flow diagram

**Comments**

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**Experiment #10**

**To study PDMT (Predetermined Motion Time analysis) through MTM-2**

**Theory**

**The Work- Factor System**

Work-Factor system was one of the first systems of predetermined motion-time data to have de general use. The first actual shop application was made in 1938, and the time vil first published in 1945 This system makes it possible to determine the normal or select time for manual tasks by the use of motion-time data. First, a detailed analysis of each task is made, based on the identification of the four major variables of work and the use of Work-Factors as a unit of measure. Then the proper standard time from the table of motion time values is applied to each motion A basic motion is defined as the motion which involves the last amount of difficulty or precision for any given distance and body member combination for example, towsing a balt in a box Work-Factor is a unit used as the index of additional time required over and above the basic time when motions are performed involving the following variables 1. Maal Control 2 Weight or Resistance

**Four Major Variables**

According to the Work-Factor system there are four major variables which affect the time to

perform manual motion. They are as follows

1.Body member used, identified by exact definition

2. Distance moved measure in inches

3.Manual control required measure in Work-Factors, defined or dimensional

4.Weight or resistance involved, measured in pounds converted to Work Facts

**Standard Elements of Work**

Work-Factor recognizes the following standard elements

1. Transport (Reach and Move) CTRP)

2 Grasp (GR)

3 Preposition (PPT) Experiment #10

**Comments**

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