PREFACE

Industrial engineering is concerned with the development, improvement, implementation and evaluation of integrated systems of people, money, knowledge, information, equipment, energy, materials, analysis and synthesis, as well as the mathematical, physical and social sciences together with the principles and methods of engineering design to specify, predict, and evaluate the results to be obtained from such systems or processes.

In this laboratory, the students will be able to:

1. Determine the time standards.
2. Prepare various types of process chart like man-machine chart, operation chart, etc.
3. Understand process capability and carry out work sampling.
4. Design various work stations according to ergonomics considerations.
5. Understand various management techniques like PPC and TQM.
6. Generate random number using simulation.

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EXPERIMENT NO-1

Objective: - Determination of time standard for a given job using stopwatch time study.

Theory:-You will see a video of short cycle task, divide the task shown video into elements, collect pilot data, and then process that data to find standard time for the task.

Time Study:
Time study is used to determine the time required by a qualified and well-trained person working at a normal pace to do a specified task. Time study is the technique for establishing an allowed time standard to perform a given task. Time study is a direct and continuous observation of a task, using a timekeeping device (e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera) to record the time taken to accomplish a task. The result of time study is the time that a person suited to the job and fully trained in the specified method will need to perform the job if he works at a normal or standard speed. This is called standard time. Divide all manual work into elements (Fundamental hand motion or Therbligs), and write down on your time study form.

1. Get the wire & circuit board
2. Assemble the wire to circuit board
3. Assemble the lower cover sub-assembly
4. Fix the upper cover
5. Get the screw and put in assembly.
6. Tight the screw with screw driver.
7. Put the final assembly in bin

Collect the pilot data using stop watch. Make sure to make appropriate notation about any parts of the task that are not usual.

Time Study sheet for Pilot data									
S.NON.	**Elements Description**	**Therblig symbol**	**Reading (time in sec)**					**Mean time**	**Standard Deviation**
			1	2	3	4	5		
1									
2									
3									
4									
5									

Time study 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.

Data Analysis:

Determine mean time and standard deviation for each element. Based on this pilot data, determine the number of cycles to observe for a full time study. (for complete operation).How many cycles should you study for 95 percent confidence level and a precision of ± 5 % How many cycles should you study for 95 percent
Confidence level and a precision of ± 10 %.
Performance rating is a part of the time study process. What rating would you provide to supplement the time data you collected? (How much did the operator produce during the time you made your observations, relative to what you would expect from a "normal" operator?) [Show all your work]
• Skill
• Effort
• Conditions
• Consistency

Normal Time = Actual time X (1 + Rating Factor)

Analysis:
Data Analysis
In order to calculate the standard time for the task, allowances are typically added. What allowances do you think should be included for this particular task? (Briefly explain your response.)
• Personnel allowance
• Fatigue Allowance
• Delay Allowance
• Calculate the standard time for the task.(Show your all work in details)
Standard time = normal time * (100/100-Allowances)
• What would the hourly production rate be for one operator? (Show your all work in details).
Hourly production = 3600/ standard time in sec.

Conducting time-studies:

According to good practice guidelines for production studies, a comprehensive time study consists of:

- Study goal setting;
- Experimental design;

- Time data collection;
- Data analysis;
- Reporting.

The collection of time data can be done in several ways, depending on study goal and environmental conditions. Time and motion data can be captured with a common stopwatch, a handheld computer or a video recorder. There are a number of dedicated software packages used to turn a palmtop or a handheld PC into a time study device. As an alternative, time and motion data can be collected automatically from the memory of computer-control machines (i.e. automated time studies).

RESULT:

VIVA VOICE:

- **Define time-study.**
- **What do you mean by standard time?**
- **When it is often used.**
- **What are the conditions for a comprehensive time study?**
- **Give an example for a time-study.**

EXPERIMENT NO.-2

OBJECTIVE: To study & preparation about flow process chart for an existing setup and development of an improved process.

THEORY: - A flowchart is a type of diagram that represents an algorithm, workflow or process, showing the steps as boxes of various kinds, and their order by connecting them with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.

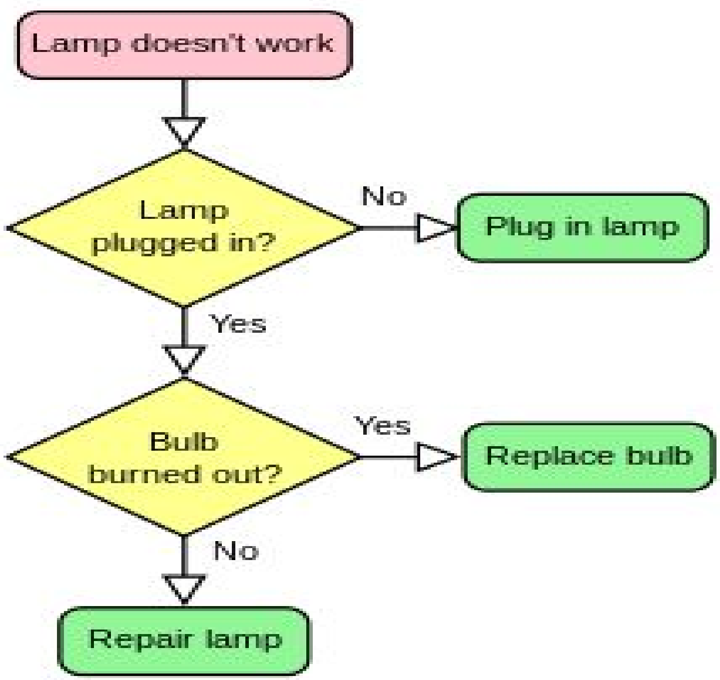


Fig. A simple flowchart representing a process for dealing with a non-functioning lamp.

The **flow process chart** in an industrial engineering is a graphical and symbolic representation of the processing activities performed on the work piece.

HISTORY: The first structured method for documenting process flow, e.g. in flow shop scheduling, the flow process chart, was introduced by Frank and Lillian Gilbreth to members of ASME in 1921 as the presentation "Process Charts, First Steps in Finding the One Best Way to Do Work". The Gilbreths' tools quickly found their way into industrial engineering curricula.

SYMBOLS: In 1947, ASME adopted the following symbol set derived from Gilbreth's original work as the ASME Standard for Process Charts.

Symbol	Letter	Description
O	O	Operation
[illegible]	I	Inspection
→	M	Move
D	D	Delay
∇	S	Storage

- **Operation**: to change the physical or chemical characteristics of the material.
- **Inspection**: to check the quality or the quantity of the material.
- **Move:** transporting the material from one place to another.
- **Delay:** when material cannot go to the next activity.
- **Storage:** when the material is kept in a safe location.

Flow process chart are of three types:

- Man, Machine and Material.
- The man type flow process chart shows the process from the point of view of man/operator. It indicates the activities of man throughout the process.

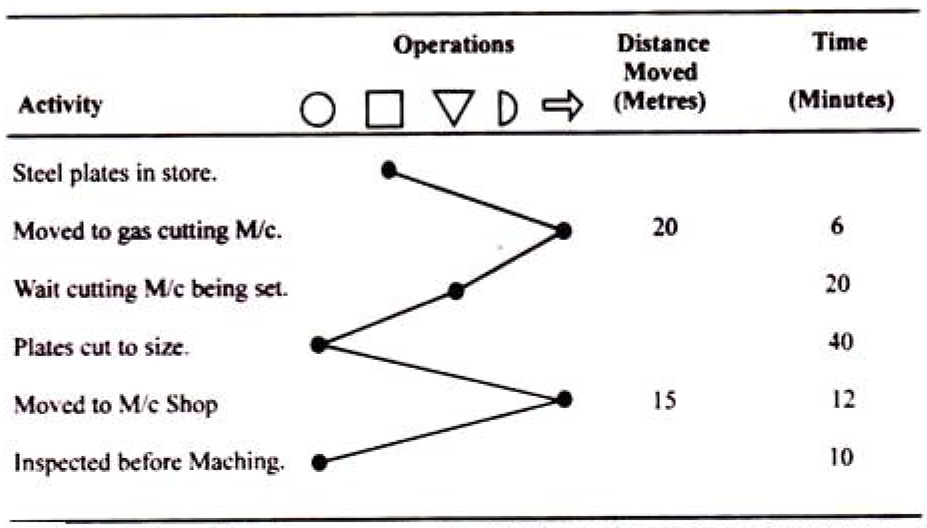


Fig. **A portion of the flow process chart (material type) showing flow of material**

- The machine type flow process chart shows the activities from the point of view of machines involved. A chart for example of a boring machine will ignore the whole of activities except the past in which boring machine is involved. It will not indicate any movement of men or materials.

- The material type flow process chart shows the process from the materials point of view utilized during the process. It shows the introduction of all materials whether raw material or finished components and represents all information regarding operations and inspections carried out on the during process diagrammatically.

WHEN TO USE IT:

- It is used when observing a physical process, to record actions as they happen and thus get an accurate description of the process.

- It is used when analyzing the steps in a process, to help identify and eliminate waste - thus, it is a phenomenal tool when it comes to efficiency planning.
- It is used when the process is mostly sequential, containing few decisions.

BENEFITS OF FLOW PROCESS CHART:

- **It helps to improve a work method by:**
  (i) Simplification of operations.

  (ii) Simplification of inspection required.

  (iii) Reduction in distance moved by men and materials in shops.

  (iv) Reduction in waiting time.

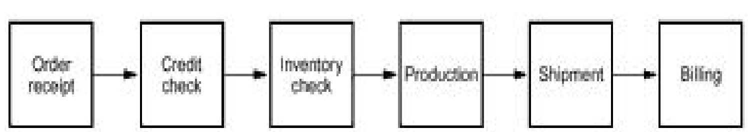
  (v) Reduction in periods of temporary storage so reduces work in process time.

FLOWCHART BASIC PROCEDURE: Materials needed: sticky notes or cards, a large piece of flipchart paper or newsprint, marking pens.

- Define the process to be diagrammed. Write its title at the top of the work surface.
- Discuss and decide on the boundaries of your process: Where or when does the process start? Where or when does it end? Discuss and decide on the level of detail to be included in the diagram.
- Brainstorm the activities that take place. Write each on a card or sticky note. Sequence is not important at this point, although thinking in sequence may help people remember all the steps.
- Arrange the activities in proper sequence.
- When all activities are included and everyone agrees that the sequence is correct, draw arrows to show the flow of the process.
- Review the flowchart with others involved in the process (workers, supervisors, and suppliers, customers) to see if they agree that the process is drawn accurately.

FLOWCHART EXAMPLE:

High–Level Flowchart for an Order-Filling Process



RESULT:

VIVA-VOICE:

- **Define flow-chart.**
- **What are the different symbols that are used in flow process chart?**
- **Explain flow process chart.**
- **What are the uses of flow process chart?**
- **Give the benefits of the flow process chart.**

EXPERIMENT NO.-3

OBJECTIVE: To study & preparation about man-machine chart for an existing setup and development of an improved process.

THEORY: A man-machine chart graphically represents the relationship between the manual work performed by one or more operators and one or more machines involved in a manufacturing process.

- A Worker-machine activity chart is a chart used to describe or plan the interactions between workers and machines over time.

- As the name indicates, the chart deals with the criteria of work elements and their time for both the worker and the machine. This chart is useful to describe any repetitive worker-machine system.

Given the different work steps required in a production process to load, operate and unload machines in conjunction with the process times of the machines themselves the man-machine chart is used to determine the highest production level that can be achieved given the resources available. This process usually involves performing as much manual work as possible internal to the machine cycles i.e. when the machine is running so that when a the machine cycle is complete the production generating machine cycle can be restarted again with as little downtime as possible.

Multiple activity charts are the process charts using a time scale. It usually comes in picture when work study man wants to record the activities of one subject with respect to other on a single chart. Subject may be the worker, machine or equipment.

Now, the type of multiple activity charts to be drawn depends upon the type of job, important types are:

(1) Man-Machine Activity Chart-when one operator is working on one machine.

(2) Multi-man Activity Chart-when a group of workers are working on a machine.

(3) Man- Multi machine activity chart- when a single operator is working on a number of machines.

(4) Multi man- Machine chart- a group of operators working on a common central machine.

This type of chart is generally used for enabling maintenance and the similar work to be organized so that the time expensive equipment out of commission can be reduced to minimum. Obviously, the complex processes can be recorded in a simpler manner. It finds its applications in planning team work and construction jobs also.

CONSTRUCTION OF CHART:

First of all, separate bars or columns are allotted to each subject. These subjects are placed against a common time scale. Activities of worker and machine are recorded by shading the respective bars or columns. Time studies conducted previously provide the time values for each activity. Now, the activities are plotted in sequence against the common time scale. A man-machine activity chart explaining the process of reading a deck of cards in card reader is drawn.

Multiple Activity Chart (Man - Machine type)

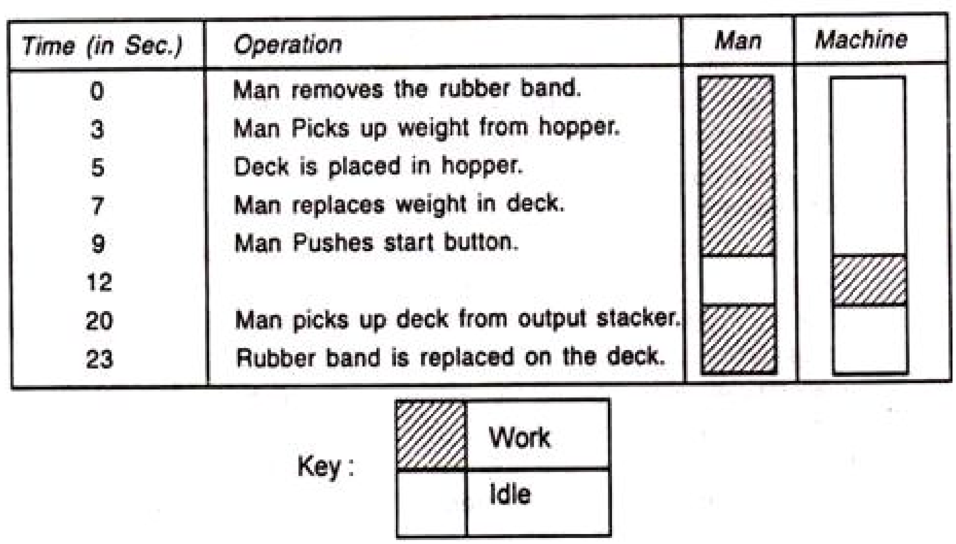


Fig. 4.8.

After constructing the chart, the first task is to analyze the idle time and always it is tried to minimize it to minimum. Operations should be simplified to their maximum. There after work distribution should be optimized between the machines and the operators.

Other aspects like to examine the inter dependency of activities, to decide the number of workers in a group etc. are also discussed on the basis of multiple activity charts. Always, the aim of the work study man is to develop a better and improved method.

A typical worker-machine activity chart consists of two main columns, one for the worker and the other the machine; in some chart formats, there is a third column showing the cumulative time. The chart can also be color-coded to convey information; for example, the time column is used to specify the activity of the worker and the machine, if the column is shaded with black color, it indicates that the worker or the machine is performing an operation, while if it is shaded with gray color, it refers to inspection. For moving, it is customary refer to it with diagonal lines, whereas horizontal lines indicate a holding activity. If the column is blank then the worker or the machine is idle. For some other uses, there is a same version to accommodate enormous worker-machine interactions, called the multiple worker-multiple machine activity chart.

USES:

- The chart can be used to investigate potential process improvements.
- It can be used to illustrate delays and redundancy, so process improvement efforts can be made to eliminate inefficiencies and identify the activities that can be combined.
- It is used to study, analyze & improve one workstation at a time.
- It shows the exact time relationship between working cycle of a person and operating cycle of machine.
- These facts can lead to utilization of both worker and machine time and a better balance of work cycle.

RESULT:

VIVA-VOICE:

- **What do you mean by man –machine chart?**
- **Define multiple activity chart.**
- **Explain the different types of multiple activity chart.**
- **What are the uses of man-machine chart.**
- **Give an example which shows the functioning of man-machine chart.**

EXPERIMENT No. 4

OBJECTIVE: To study about operation process chart.

THEORY: This is also known as outline process chart and it provides a compact over all view of the whole system of operations involved in the production of a product. In this chart only the main activities (i.e. operations and inspections) carried out to complete a job are recorded in the sequence of their occurrence but irrespective of where they are performed and who performs them.

The **operation chart** is a graphical and symbolic representation of the manufacturing operations used to produce a product. The operation chart illustrates only the value-adding activities in the manufacturing process; therefore, material handling and storage are not illustrated in this chart.

Thus only symbols of process chart are used in preparing it. Sometimes a brief note about the nature each activity (may be operation or inspection) and the time allowed are mentioned by the side of symbols. The processing to material i.e. various activities is shown vertically on the entry or purchase of material by horizontal lines as shown in Figure. (The operation process chart for the fabrication of a riveted assembly).

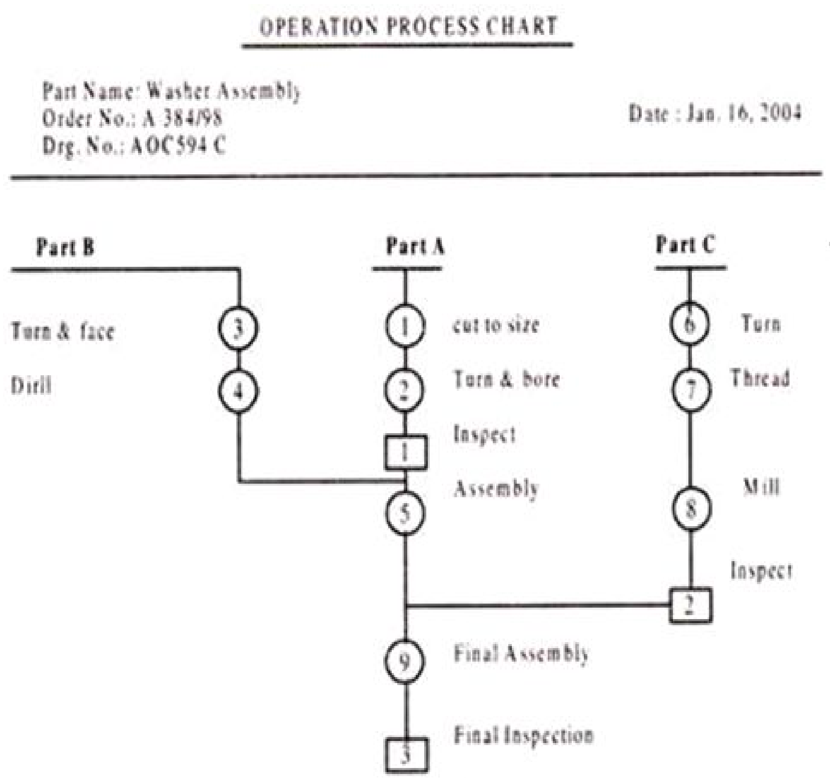


Figure: Fabrication of a riveted assembly

An operation process chart has following advantages:

(i) To improve shop/plant layout.

(ii) Helps in specifying the basic manufacturing system.

(iii) Helps in determining sequence of assembly and the scheduling activities regarding dates of purchased material and completion dates for fabricated parts.

(iv) To introduce the new technical personal with the manufacturing system.

RESULT:

VIVA-VOICE:

- **Define operation process chart.**
- **What do you mean by operation chart.**
- **What are the advantages of operation process chart.**
- **Give an example of operation process chart.**

EXPERIMENT NO-5

OBJECTIVE: To carry out a work sampling study.

THEORY: Work Sampling

Work Sampling (also sometimes called ratio delay study) is a technique of getting facts about utilization of machines or human beings through a large number of instantaneous observations taken at random time intervals. The ratio of observations of a given activity to the total observations approximates the percentage of time that the process is in that state of activity. For example, if 500 instantaneous observations taken at random intervals over a few weeks show that a lathe operator was doing productive work in 365 observations and in the remaining 135 observations he was found 'idle' for miscellaneous reasons, then it can be reliably taken that the operator remains idle (135/500) x 100 = 27 % 0f the time. Obviously, the accuracy of the result depends on the number of observations. However, in most applications there is usually a limit beyond which greater accuracy of data is not economically worthwhile.

Work sampling is the statistical technique for determining the proportion of time spent by workers in various defined categories of activity (e.g. setting up a machine, assembling two parts, idle…etc.). It is as important as all other statistical techniques because it permits quick analysis, recognition, and enhancement of job responsibilities, tasks, performance competencies, and organizational work flows. Other names used for it are 'activity sampling', 'occurrence sampling', and 'ratio delay study'.

In a work sampling study, a large number of observations are made of the workers over an extended period of time. For statistical accuracy, the observations must be taken at random times during the period of study, and the period must be representative of the types of activities performed by the subjects.

One important usage of the work sampling technique is the determination of the standard time for a manual manufacturing task. Similar techniques for calculating the standard time are time study, standard data, and predetermined motion time systems.

Use of Work Sampling for Standard Time Determination:

Work sampling can be very useful for establishing time standards on both direct and indirect labor jobs. The procedure for conducting work sampling study for determining standard time of a job can be described step-wise.

Step 1. Define the problem.

• Describe the job for which the standard time is to be determined.

• Unambiguously state and discriminate between the two classes of activities of operator on the job: what are the activities of job that would entitle him to be in 'working" state.

This would imply that when operator will be found engaged in any activity other than those would entitle him to be in "Not Working" state.

Step 2. Design the sampling plan.

• Estimate satisfactory number of observations to be made.

• Decide on the period of study, e.g. two days, one week, etc.

• Prepare detailed plan for taking the observations.

This will include observation schedule, exact method of observing, design of observation sheet, route to be followed, particular person to be observed at the observation time, etc.

Step 3. Contact the persons concerned and take them in confidence regarding conduct of the study.

Step 4. Make the observations at the pre-decided random times about the working / not working state of the operator. When operator is in working state, determine his performance rating. Record both on the observation sheet.

Step 5. Obtain and record other information. This includes operator's starting time and quitting time of the day and total number of parts of acceptable quality produced during the day.

Step 6. Calculate the standard time per piece.

Characteristic of work sampling study:

The study of work sampling has some general characteristics related to the work condition:

- One of them is the sufficient time available to perform the study. A work sampling study usually requires a substantial period of time to complete. There must be enough time available (several weeks or more) to conduct the study.
- Another characteristic is multiple workers. Work sampling is commonly used to study the activities of multiple workers rather than one worker.
- The third characteristic is long cycle time. The job covered in the study has relatively a long cycle time.
- The last condition is the non-repetitive work cycles. The work is not highly repetitive. The jobs consist of various tasks rather than a single repetitive task. However, it must be possible to classify the work activities into a distinct number of categories.

We will now briefly discuss some important issues involved in the procedure.

Number of Observations:

As we know, results of study based on larger number of observations are more accurate, but taking more and more observations consumes time and thus is costly. A cost-benefit trade-off has thus to be struck. In practice, the following methods are used for estimation of the number of observations to be made.

(i) **Based on judgment**. The study person can decide the necessary number of observations based on his judgment. The correctness of the number may be in doubt but estimate is often quick and in many cases adequate.

(ii) **Using cumulative plot of results.** As the study progresses the results of the proportion of time devoted to the given state or activity, i.e. Pi from the cumulative number of observations are plotted at the end of each shift or day.

(iii) **Use of statistics**. In this method, by considering the importance of the decision to be based on the results of study, a maximum tolerable sampling error in terms of confidence level and desired accuracy in the results is specified.

The number of observations estimated from the above relation using a value of Pi obtained from a preliminary study would be only a first estimate. In actual practice, as the work sampling study proceeds, say at the end of each day, a new calculation should be made by using increasingly reliable value of Pi obtained from the cumulative number of observations made.

Determination of Observation Schedule:

The number of instantaneous observations to be made each day mainly depends upon the nature of operation. For example, for non-repetitive operations or for operations in which some elements occur in-frequently, it is advisable to take observations more frequently so that the chance of obtaining all the facts improves. It also depends on the availability of time with the person making the study. In general, about 50 observations per day is a good figure. The actual random schedule of the observations is prepared by using random number table or any other technique.

Design of Observation Sheet:

A sample observation sheet for recording the data with respect to whether at the pre-decided time, the specified worker on job is in 'working' state or 'non-working' state is shown in . It contains the relevant information about the job, the operators on job, etc. At the end of each day, calculation can be done to estimate the percent of time workers on the job (on an average) spend on activities, which are considered as part of the job.

Conducting Work Sampling Study:

At the predecided times of study, the study person appears at the work site and observes the specific worker (already randomly decided) to find out what is he doing. If he is doing activity which is part of the job, he is ticked under the column 'Working' and his performance rating is estimated and recorded. If he is found engaged in an activity which is not a part of job, he is ticked under the column 'Not Working'. At the end of day, the number of ticks in 'Working' column is totaled and average performance rating is determined.

The observed time (OT) for a given job is estimated as:

$$S.P_i = x\sqrt{\frac{P_i(1-P_i)}{N}}$$

Where S = desired relative accuracy

P_i = estimate of proportion of time devoted to activity, expressed as a decimal, e.g. 5 % = 0.05

x = a factor depending on the confidence level.

x = 1, 2, 3 for confidence levels of 68 %, 95 % and 99 % respectively.

N = total number of observations needed.

The normal time (NT) is found by multiplying the observed time by the average performing index (rating factor).

$$NT = OT \times \left(\bar{R}/100\right)$$

$$\frac{(\Sigma R)}{n_1}$$

Where = $\bar{R}$ is average rating factor to be determined as,

The standard time is determined by adding allowances to the normal time.

RESULT:

VIVA VOICE:

- Define work sampling.
- Explain the different types of steps involved in work sampling techniques.
- What are the uses of this technique?
- What are the characteristic of work sampling techniques?
- How can you calculate the observed time (OT) for a given job?

EXPERIMENT NO.-6

OBJECT:-To design a sampling scheme based on OC curve.

INTRODUCTION: - SAMPLING

In statistics, quality assurance, and survey methodology, **sampling** is concerned with the selection of a subset of individuals from within a statistical population to estimate characteristics of the whole population. Each observation measures one or more properties (such as weight, location, color) of observable bodies distinguished as independent objects or individuals. In survey sampling, weights can be applied to the data to adjust for the sample design, particularly stratified sampling. Results from probability theory and statistical theory are employed to guide the practice. In business and medical research, sampling is widely used for gathering information about a population.

The sampling process comprises several stages:

- Defining the population of concern.
- Specifying a sampling frame, a set of items or events possible to measure.
- Specifying a sampling method for selecting items or events from the frame.
- Determining the sample size.
- Implementing the sampling plan.
- Sampling and data collecting.
- Data which can be selected.

SAMPLING SCHEME: It is a collection of sampling plans . A sampling plan applies to the sample size based on a specific inspection lot quantity and defines the criteria for determining whether and how a sample is accepted or rejected. In the SAP system, the structure of the sampling plans complies with international standards (for example ISO 2859 and ISO 3951). However, you can also add sampling schemes for different sampling procedures.

You can use a sampling scheme if you want to:

- Determine the sample size on the basis of the lot size, inspection severity, or combination of inspection severity and AQL (actual quality level)
- Store how a decision is made to accept or reject a characteristic
- Determine the number of physical samples, based on the lot size, or the number of containers in an inspection lot in sample management.

Acceptance sampling: It is an inspecting procedure applied in statistical quality control. It is a method of measuring random samples of populations called “lots” of materials or products against predetermined standards. Acceptance sampling is a part of operations management or of accounting auditing and services quality supervision. It is important for industrial, but also for business purposes helping decision-making process for the purpose of quality management.

Sampling plans are hypothesis tests regarding product that has been submitted for an appraisal and subsequent acceptance or rejection. The products may be grouped into batches or lots or may be single pieces from a continuous operation. A random sample is selected and could be checked for various characteristics. For lots, the entire lot is accepted or rejected in the whole. The decision is based on the pre-specified criteria and the amount of defects or defective units found in the sample. Accepting or rejecting a lot is analogous to not rejecting or rejecting the null hypothesis in a hypothesis test. In the case of continuous production process, a decision may be made to continue sampling or to check subsequent product 100%.

If the quality controls have broken down, the sampling will prevent defective products from passing any farther. There are a number of different methods widely used for selecting a product for checking quality characteristics:

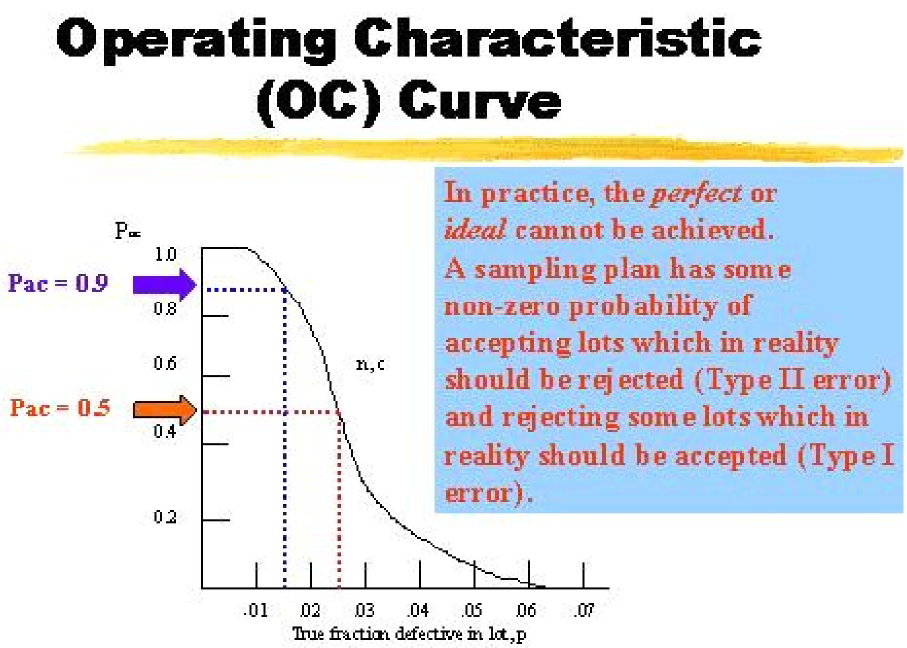
(1) No checking
(2) 100% checking
(3) Constant percentage sampling
(4) Random spot checking
(5) Audit sampling (with no acceptance and rejection criteria); and (6) Acceptance sampling.

Problem Formulation: Types of Risks in Acceptance Sampling because an entire lot of material is not being inspected, not everything is known, and so, sampling will always incur certain risks. This incurs the risk of making two types of errors in «the accept: not accept» decision. *ƒ* A lot may be rejected that should be accepted and the risk of doing this is the producer's risk.

The second error is that a lot may be accepted that should have been rejected and the risk of doing this is called the consumer's risk. But, it is a good thing that these two risks could be measured.

The Type I Error, called significance level, is preset on with quite low level, most at 5% (or 1% or 10%), to protect of this type of error. It is true that:
α = P{Type I Error}
α = P { rejected H H is true 0 0 } and
β = P{not rejected H H is false 0 0 }
β = P{Type II Error}.
The power of the test is equal to: Power P rejected H H is false =− = 1 β { 0 0 }. (4)

Operating Characteristic (OC) Curve: Analysts create a graphic display of the performance of a sampling plan by plotting the probability of accepting the lot for a range of proportions of defective units. This graph, called an OC curve, describes how well a sampling plan discriminates between good and bad lots. Undoubtedly, every manager wants a plan that accepts lots with a quality level better than the AQL 100 percent of the time and accepts lots with a quality level worse than the AQL zero percent of the time. An OC curve is developed by determining the probability of acceptance for several values of incoming quality. An OC curve showing producer's risk α and consumer's risk β is given in Fig.



RESULT:

VIVA VOICE:

- Define sampling.
- What are the different stages of sampling process?
- What do you mean by acceptance sampling?
- Define Operating Characteristic (OC) Curve for sampling scheme.

EXPERIMENT NO-7

OBJECT: To conduct Shewart's experiments on known population.

INTRODUCTION

Statistical process control (SPC) is not a magic formula for curing all production ills; it is a very useful tool to be used in promoting and maintaining the health of a commercial or industrial enterprise.

The first step in SPC is to define the process from the point of the view of the financial manager. Then, the characteristics of the process are observed and measured over time. The numbers obtained from these observations are used to monitor the process by calculating the average and examining the natural variation around the average (mean) over time. This method of studying the variation from the mean is known as control charting, as it pinpoints if the process has encountered any special variation that needs special attention. Control charts that depict no special problems indicate that the process is in control and predictable. However, if the control charts show unusual variations (by points outside the acceptable range) it may indicate some problem within the process. Usually the problem is caused by a temporary circumstance and thus, can be resolved by a localized solution rather than changing the general policy. It is worth noting here that SPC is used:

1- To improve quality.

2- To increase yield (or maintain yield at reduced cost).

Parts of SPC:

The SPC methods can be described as two parts:

1- ON-LINE SPC methods.

2- OFF-LINE SPC methods.

ON-LINE SPC : This method is divided into two types, screening or preventative.

In screening, we inspect the output, and if the quality is not satisfactory, we screen out the substandard items for reworking, for selling at a reduced price or for scrap. This is usually done by a system of sampling inspection. Screening for quality is usually very expensive, and not recommended.

In preventative SPC methods we inspect the process, and try to use process control to avoid defective items being produced.

Some people contrast control charts, as preventative methods, with sampling inspection as a screening procedure. This distinction is not correct. Control charts can be used as a screening mechanism, and sampling inspection can be used in a preventative manner. But the importance of on-line SPC methods lies in their use as preventative procedures.

SPC methods concentrate on trying to control process average level and process spread. In particular, process spread or variability is a special enemy of quality, and needs to be tackled with some vigour. Indeed the vast majority of discussions on quality between manufacturers, their customers and suppliers is centered around the consistency of feed stocks and products.

OFF- LINE SPC : This is often the next stage on from on-line SPC, although ideally it should be built into designing and setting up a product and its production process from the start.

The aim is to reduce or remove the effect of potential causes of variability by modifying the process, or the product, so making it less sensitive to these causes. This generally requires skill and ingenuity from a team of people with different expertise.

Basic Shewart control charts for continuous variables.

The idea of the control chart is to operate a simple mechanism for controlling the average level and spread of a process. A minimum of two charts is required. one to control process average level and one to control process spread.

In control - Out of control

In any production process, some variation in quality is unavoidable, and the theory behind the control chart originated by Dr W. A. Shewhart is that this variation can be divided into two categories.

random variation. and variation due to special or assignable causes. Variations in quality which are due to causes over which we have some degree of control. Such as a different quality of raw material, or new and unskilled workers are called special causes of variation.

The random variation is the variation in quality which is the result of many complex causes, the result of each cause being slight. By, and large nothing can be done about this source of variation except to modify the process.

If data from a process are such that they might have come from a single distribution, having certain desired properties such as a mean in a specified range, the process is said to be in control.

If, on the other hand, variation due to one or more special causes is present, the process is said to be out of control. The Shewhart control chart is a simple device which enables us to define this stale of statistical control more precisely, and which also enables us to judge when it has been attained.

Sampling Risks

When operating SPC we take small samples from the process at regular intervals and plot, Say, the mean and the range on a chart. As a result, we conclude that the process is either in control or out of control. If the process is out of control. this may be due to a change in process average level, or process spread. or due to a particular problem at a specified time point. Because of the variation inherent in sampling. the average levels and the spreads as indicated by the samples will vary from sample to sample even if the true process average and spread are constant. This gives rise to two dangers when sample observations are plotted on a control chart. These are as follows:

Type I risk: The risk that a legitimately extreme sample will give a spurious 'action' decision when no change has occurred in the process.

Type II risk: The risk that a sample will fall within the control limits although there has been a real change in the process: the change is not signalled. (The size of this risk will get smaller as the size of the change increases.)

Control Charts for Average Level:

-Charts: Chart Construction:

The construction of an $\bar{x}$ -chart relies on having good estimates $\hat{\mu}$ of the process average level and $\hat{\sigma}_e$, of the standard error of the group means.

These estimates are derived either from data from process capability studies. or from fresh data.

Method summary:

Construction of $\bar{x}$ -Chart:

Step 1 Obtain estimates of the process average level, $\hat{\mu}$, and the process variability, and also obtain the estimated standard error of group means, $\hat{\sigma}_e$.

Step 2 Choose the scale of the chart so that $\hat{\mu}$ is near the centre. and so that the scale covers approximately $\pm 4\hat{\sigma}_e$, from $\hat{\mu}$. where n is the sample size at each sampling point.

Step 3 Mark the action lines at $\hat{\mu} \pm 3.09\hat{\sigma}_e$ (probability); $\hat{\mu} \pm 3\hat{\sigma}_e$ (popular)

Step 4 Mark the warning lines at $\hat{\mu} \pm 1.96\hat{\sigma}_e$ (probability) $\hat{\mu} \pm 2\hat{\sigma}_e$ (popular)

Charts for Control of (Within-Group) Process Spread:

Range Charts – Construction:
There are two ways of setting up the range chart - the 'range' method and the 'σ' method. If process capability data are used to get an estimate of σ_w, then this is fed into the appropriate step of the a method. These methods are set out below.

Method Summary:

Construction of A Range Chart by The Range Method:

Step 1 Obtain the average range $\bar{R}$ either from process capability studies data. or from at least 20 groups of fresh data.
Step 2 Choose the scale of the range chart so that the range goes down to zero, and up to about twice the largest range observed in the trial data sets.
Step 3 Mark the action and warning limits on the chart:

Lower action limit: $D_1\bar{R}$

Upper action limit: $D_2\bar{R}$

Lower warning limit: $D_3\bar{R}$

Upper warning limit: $D_4\bar{R}$

where the D_1, D_2, D_3 and D_4 values are given in Table (factors for Construction range charts from an average. The factors are obtained from the distribution of the range in Normal samples, and from the conversion factors from range to estimates of σ).

RESULT:

VIVA VOICE:

- What do you mean by Statistical process control? (SPC)
- Define control charting.
- What are the different parts of SPC methods.
- What do you mean by sampling risks.
- Explain the benefits of SPC.

EXPERIMENT No. 8

OBJECTIVE: To study about process capability for a machine in the workshop.

1. INTRODUCTION:

Suitable methods must be applied for monitoring, and where applicable, measurement of processes. "These methods shall demonstrate the ability of the processes to achieve planned results. When planned results are not achieved, correction and corrective action shall be taken, as appropriate, to ensure conformity of the product."

Examples of characteristics to assess the process performance or capability are or include the following:

Capability indices
Cycle time or throughput
Rate of yield
Use of suitable technology
Avoidance and reduction of waste
Response time
Reliability and safety
Effectiveness and efficiency
Costs

2. Terms

Process: This document deals exclusively with production and assembly processes. A process is understood as a series of activities or procedures in which raw materials or pre-machined parts or components are further processed to generate a finished product. The definition in the standard is as follows: “Set of interrelated or interacting activities which transforms inputs into outputs.”

Capability Studies: A process capability study is performed for a new or changed production process (including assembly) in order to verify the (preliminary) process capability or performance and to obtain additional inputs for controlling the process. In a short-term study (e.g., machine capability study), characteristics of products manufactured in one continuous production run are evaluated. A long term study evaluates parts manufactured over a longer time-span which is representative of the variation encountered in series production.

Capability and Performance Indices: Quantitative measures for evaluating capability include the machine and process capability or process performance indices. These must achieve or surpass the specified minimum values.

Machine Capability Study: The machine capability study is a short-term study with the sole aim of discovering the machine-specific effects on the production process.

Process Capability Study: The process capability study is a longer-term study. In addition to variation arising from the machine, all other external factors that influence the production process over a longer operating time must be taken into account.

Stable Process: A stable (in statistical control) process is only subject to random influences. In particular, the location and variation of the product characteristic are stable over time.

Capability Indices Cmk, Cpk and Performance Index Ppk: In accordance with the QS-9000, the term Cpk must only be used for a stable process. A process is stable if the following synonymous statements apply to it:

- Mean and variance are constant.
- No systematic variations of the mean such as trend, batch-to-batch variation, etc., occur.
- There is no significant difference between sample variation and total variation.
- Every sample represents the location and variation of the total process.

If the process is not stable, one speaks of “process performance”, and the index is called the process performance index, Ppk. This applies to all processes with systematic variation of the mean such as trend or batch-to-batch variation.It is, therefore, the process behavior which determines whether the index is named Cpk or Ppk.

In a machine capability study (“initial process study” or “short term study”) the index is always called Cmk, except where different customer requirements are specified. Cmk is understood to be an index for a short-term capability study.

3. Process Capability Index

Cm (capability machine): The Cm index describes machine capability; it is the number of times the spread of the machine fits into the tolerance width. The higher the value of Cm, the better the machine.

Example: if Cm = 2.5, the spread fits 2½ times into the tolerance width, while Cm = 1 means that the spread is equal to the tolerance width.

Cmk (capability machine index): If you also want to study the position of the machine's capability in relation to the tolerance limits, you use the Cmk index, which describes the capability corrected for position. It is not much use having a high Cm index if the machine setting is way off centre in relation to the middle of the tolerance range.

A high Cmk index means, then, that you have a good machine with a small spread in relation to the tolerance width, and also that it is well centred within that width. If Cmk is equal to Cm, the machine is set to produce exactly in the middle of the tolerance range. A normal requirement is that Cmk should be at least 1.67

- Cp (capability process): The Cp index describes process capability; it is the number of times the spread of the process fits into the tolerance width. The higher the value of Cp, the better the process.

A high Cpk index means, then, that you have a good process with a small spread in relation to the tolerance width, and also that it is well centred within that width. If Cpk is equal to Cp, the process is set to produce exactly in the middle of the tolerance range. A normal requirement is that Cpk should be at least 1.33.

RESULT:

VIVA-VOICE:

- **What do you mean by process capability?**
- **Explain process capability index.**
- **How can you say that a process will be stable?**
- **Define process for a process capability for a machine.**

EXPERIMENT-09

OBJECTIVE: Study of existing layout of a workstation with respect to controls & displays and suggesting improved design from ergonomic viewpoint.

THEORY: A workstation is a special computer designed for technical or scientific applications. Intended primarily to be used by one person at a time, they are commonly connected to a local area network and run multi-user operating systems. The term workstation has also been used loosely to refer to everything from a mainframe computer terminal to a PC connected to a network, but the most common form refers to the group of hardware offered by several current and defunct companies such as Sun Microsystems, Silicon Graphics, Apollo Computer, DEC, HP and IBM which opened the door for the 3D graphics animation revolution of the late 1990s.

Workstations offered higher performance than mainstream personal computers, especially with respect to CPU and graphics, memory capacity, and multitasking capability. Workstations were optimized for the visualization and manipulation of different types of complex data such as 3D mechanical design, engineering simulation (e.g., computational fluid dynamics), animation and rendering of images, and mathematical plots.

WORKSTATION LAYOUT:

This section on workstation layout covers the following areas: general workstation design factors, control/display placement and integration, human/workstation configuration, and specialized workstation requirements.

General Workstation Design Factors-

Some workstation interactions will be complex, involving many subtasks. The designer must determine how the performance of these subtasks will be divided between humans and machines. The goal is to achieve the most effective overall system, making best use of the different capabilities of humans and machines. In making this decision, the following factors should be considered:

a. Functional analysis of the subtasks.

b. Human capabilities and cognitive load limitations.

c. Machine capabilities.

d. Human/machine integration capabilities.

e. Task analysis to ensure smooth integration of human and machine functions.

Workstation Color Design Requirements:

Workstation color selection requirements are specified below.

a. Color Selection - Neutral colors shall be used in workstations.

b. Reflections - Workstation surface colors shall be lusterless.

c. Controls-

1. Controls shall be black or gray unless special functions dictate otherwise (e.g., emergency evacuation controls are striped black and yellow).

2. Toggle switch handles shall have a satin metallic finish.

3. Control colors shall provide good contrast between controls and background.

d. Panel Color Finish - The panel color shall provide good contrast between the labels and background. Label/background colors shall be consistent within a functional area.

Control/Display Placement and Integration Design Considerations:

A) Control Spacing Design Requirements: Requirements for control spacing are provided below.

a. Normal Spacing - Minimum and preferred spacing for different types of controls (for the ungloved condition) shall be shown in Fig.

b. Gloved Operation - All space modules shall have those controls necessary for maintenance and recovery following a depressurization (e.g., as a result of a micro-meteoroid hit), operable by a pressure-suited crewmember.

c. Miniature controls - Spacing of miniature controls, intended for ungloved hand operation, shall maintain the same clearance footprint about each control (i.e., the edge-to-edge separation between the pair of controls located on either side of a third control).

ERGONOMICS: It is the process of designing or arranging workplaces, products and systems so that they fit the people who use them.

Most people have heard of ergonomics and think it is something to do with seating or with the design of car controls and instruments – and it is… but it is so much more. Ergonomics applies to the design of anything that involves people – workspaces, sports and leisure, health and safety.

Ergonomics (or 'human factors' as it is referred to in North America) is a branch of science that aims to learn about human abilities and limitations, and then apply this learning to improve people's interaction with products, systems and environments.

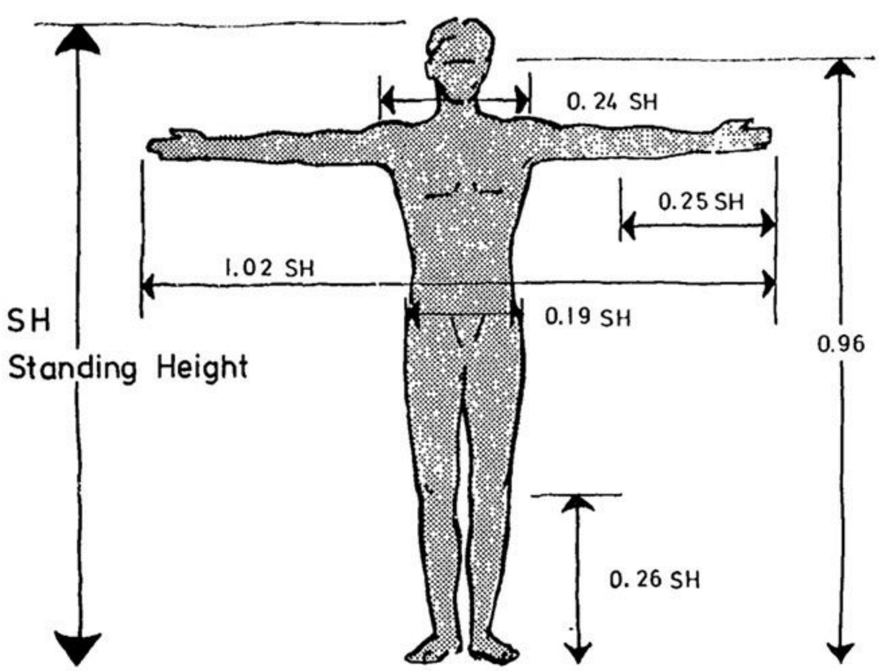
Ergonomics aims to improve workspaces and environments to minimize risk of injury or harm. So as technologies change, so too does the need to ensure that the tools we access for work, rest and play are designed for our body's requirements.

Why is Ergonomics important?

- **In the workplace:** According to Safe Work Australia, the total economic cost of work-related injuries and illnesses is estimated to be $60 billion dollars. Recent research has shown that lower back pain is the world's most common work-related disability – affecting employees from offices, building sites and in the highest risk category, agriculture.

Ergonomics aims to create safe, comfortable and productive workspaces by bringing human abilities and limitations into the design of a workspace, including the individual's body size, strength, skill, speed, sensory abilities (vision, hearing), and even attitudes.

- **In the greater population**: The number of people in Australia aged 75 and over is forecast to double over the next 50 years. With this, equipment, services and systems will need to be designed to accommodate the increasing needs of the ageing population, applying to public transport, building facilities, and living spaces.



Guidelines for Layout around the Workstation:

Guidelines for Layout around the Workstation to Increase Productivity of Operator Motions. The guidelines are based on principles of motion economy only.

(1) Both hands have to be utilized for productive work. If similar work is being done by each hand, there should be separate bins for supply of materials or parts for each hand.

(2) If the eyes are used to select material, as far as possible the material should be kept in an area where the eyes can locate it without there being any need to turn the head.

(3) Use semi-circular arrangements as hands can move over semicircle only in sitting position.

(4) Provide comfortable seating Design the workplace using anthropometric data.

(5) Hand tools should be picked up with the least possible disturbance to the rhythm and symmetry of movements. As far as possible the operator should be able to pick up or put down a tool as the hand moves from one part of the work to the next, without making a special movement.

(6) As curved movements take less time compared to straight line movements and reversals, tools should be placed on the arc of movements, but they have to be away from the path of movement of material or components from bin to the work place.

(7) Tools should be easy to pick up and replace; as far as possible they should have an automatic return, or they should be at the place close to the location of the next piece of material to be moved so that tool can be released and the material can be picked up.

(8) Finished work should be:

(a) Dropped down a hole or a chute using a foot movement.

(b) Dropped through a chute, as the hand making the first motion of the next cycle;

(c) Put in a container placed so that hand movements are kept to a minimum;

(d) Placed in a container in such a way that the next operative can pick it up easily.

(09) Always look into the possibility of using pedals or knee-operated levers for locking or indexing devices on fixtures or devices for disposing of finished work.

RESULT:

VIVA-VOICE:

- **What do you mean by work station?**
- **What are the different areas that cover the work station?**
- **List for the requirements of control spacing.**
- **Define the term “ergonomics”.**
- **Why the ergonomics is so important.**
- **What are guidelines for the layout around the workstation?**

EXPERIMENT NO.-10

OBJECTIVE: Generation of random numbers for system simulation such as facility planning and job shop scheduling.

THEORY: A **random-number generator** (**RNG**) is a computational or physical device designed to generate a sequence of numbers or symbols that cannot be reasonably predicted better than by a random chance.

Various applications of randomness have led to the development of several different methods for generating random data, of which some have existed since ancient times, among their ranks are well known "classic" examples, including the rolling of dice, coin flipping, the shuffling of playing cards, the use of yarrow stalks (for divination) in the I Ching, as well as countless other techniques. Because of the mechanical nature of these techniques, generating large numbers of sufficiently random numbers (important in statistics) required a lot of work and/or time. Thus, results would sometimes be collected and distributed as random number tables. Nowadays, after the advent of computational random-number generators, a growing number of government-run lotteries and lottery games have started using RNGs instead of more traditional drawing methods. RNGs are also used to determine the odds of modern slot machines.

Several computational methods for random-number generation exist. Many fall short of the goal of true randomness, although they may meet, with varying success, some of the statistical tests for randomness intended to measure how unpredictable their results are (that is, to what degree their patterns are discernible). However, carefully designed cryptographically secure computationally based methods of generating random numbers also exist, such as those based on the Yarrow algorithm, the Fortuna (PRNG), and others.

USES:

- Random number generators are very useful in developing Monte Carlo-method simulations, as debugging is facilitated by the ability to run the same sequence of random numbers again by starting from the same random seed.
- They are also used in cryptography – so long as the seed is secret. Sender and receiver can generate the same set of numbers automatically to use as keys.
- The generation of pseudo-random numbers is an important and common task in computer programming. While cryptography and certain numerical algorithms require a very high degree of apparent randomness, many other operations only need a modest amount of unpredictability.

- Some simple examples might be presenting a user with a "Random Quote of the Day", or determining which way a computer-controlled adversary might move in a computer game.

SYSTEMS SIMULATION: It is a set of techniques that use computers to imitate the operations of various real-world tasks or processes through simulation. Computers are used to generate numeric models for the purpose of describing or displaying complex interaction among multiple variables within a system. The complexity of the system arises from the stochastic (probabilistic) nature of the events, rules for the interaction of the elements and the difficulty in perceiving the behavior of the systems as a whole with the passing of time.

Methods of obtaining random numbers:

- Using physical device.
- Random number tables.
- Using digital computers.
- Use of an electronic device.
- Pseudo Random number (congruential method):-
    - Mixed congruential method
    - Additive congruential method
    - Multiplicative congruential method

Mixed congruential method:

- The sequence of random numbers is generated by always calculating the next random number from the last one obtained.
- The initial random number 'x_0' is called "seed", which may be obtained from some published source.
- The method is

$$X_{n+1} = (ax_n + c) \quad \text{(modulo m)}$$

Where a, c, m are positive integer ($a < m$, $c < m$), it signifies that X_{n+1} is remainder when $(ax_n + c)$ is devided by m.

- Suppose m = 100; a = 21; c = 53 and $x_0 = 46$

then $x_1 = (ax_0 + c) / m = (21 * 46 + 53) / 100 = 1019 / 100$

$= 10 +$ remainder **19**

$X_2 = (ax_1 + c) / m = (21 * 19 + 53) / 100 = 452 / 100$

$= 4 +$ remainder **52**

$X_3 = (ax_2 + c) / m = (21 * 52 + 53) / 100 = 1145 / 100$

$= 11 +$ remainder **45**

Therefore the required two digit random numbers are 19, 52, 45, 78, 91.

Additive congruential method:

- It is similar to Mixed congruential method, but it sets a = 1, and replaces c by some random numbers preceding x_n.
- $X_{n+1} = (1*x_n + c)$ (modulo m) $x_0 = 46$

Therefore

$x_1 = (x_0 + c) / m = (46 + 53) / 100 = 99 / 100$

$= 0 +$ remainder **99**

$x_2 = (x_1 + c) / m = (99 + 53) / 100 = 152 / 100$

$= 1+$ remainder **52**

$x_3 = 1 +$ remainder **05**

Multiplicative congruential method:

- It is a special case of the mixed congruential method where c =0
- $X_{n+1} = (21*x_n)$ (module 100), $x_0 = 46$

Therefore

$x_1 = 9 +$ remainder **66**

$x_2 = 13 +$ remainder **86**

$x_3 = 18 +$ remainder **06**

RESULT:

VIVA-VOICE:

- What do you mean by RNG?
- List the applications of RNG.
- Generate a sequence of 5 three- digit random numbers, such that

$$X_{n+1} = (301 * x_n + 503) \quad \text{(modulo 1000)} \qquad x_0 = 500$$

Using mixed congruential method.

EXPRIMENT NO-11

OBJECTIVE: To detailed study of Production Planning and Control in an industrial management.

THEORY: For efficient, effective and economical operation in a manufacturing unit of an organization, it is essential to integrate the production planning and control system. Production planning and subsequent production control follow adaption of product design and finalization of a production process.

Production planning and control address a fundamental problem of low productivity, inventory management and resource utilization.

Production planning is required for scheduling, dispatch, inspection, quality management, inventory management, supply management and equipment management. Production control ensures that production team can achieve required production target, optimum utilization of resources, quality management and cost savings.

Planning and control is an essential ingredient for success of an operation unit. The benefits of production planning and control are as follows:

a) It ensures that optimum utilization of production capacity is achieved, by proper scheduling of the machine items which reduces the idle time as well as over use.

b) It ensures that inventory level is maintained at optimum levels at all time, i.e. there is no over-stocking or under-stocking.

c) It also ensures that production time is kept at optimum level and thereby increasing the turnover time.

d) Since it overlooks all aspects of production, quality of final product is always maintained.

Production Planning:

Production planning is one part of production planning and control dealing with basic concepts of what to produce, when to produce, how much to produce, etc. It involves taking a long-term view at overall production planning. Therefore, objectives of production planning are as follows:

a) To ensure right quantity and quality of raw material, equipment, etc. are available during times of production.

b) To ensure capacity utilization is in tune with forecast demand at all the time.

OBJECTIVES OF PRODUCTION PLANNING:

A well thought production planning ensures that overall production process is streamlined providing following benefits:

a) Organization can deliver a product in a timely and regular manner.

b) Supplier is informed well in advance for the requirement of raw materials.

c) It reduces investment in inventory.

d) It reduces overall production cost by driving in efficiency.

Production planning takes care of two basic strategies' product planning and process planning. Production planning is done at three different time dependent levels i.e. long-range planning dealing with facility planning, capital investment, location planning, etc.; medium-range planning deals with demand forecast and capacity planning and lastly short term planning dealing with day to day operations.

Production Control:

Production control looks to utilize different type of control techniques to achieve optimum performance out of the production system as to achieve overall production planning targets. Therefore, objectives of production control are as follows:

a) Inventory management

b) Organize the production schedules

c) Optimum utilization of resources and production process

The advantages of robust production control are as follows:

a) Ensure a smooth flow of all production processes

b) Ensure production cost savings thereby improving the bottom line

c) Control wastage of resources

d) It maintains standard of quality through the production life cycle.

Production control cannot be same across all the organization. Production control is dependent upon the following factors:

a) Nature of production (job oriented, service oriented, etc.)

b) Nature of operation

c) Size of operation

Production planning and control are essential for customer delight and overall success of an organization.

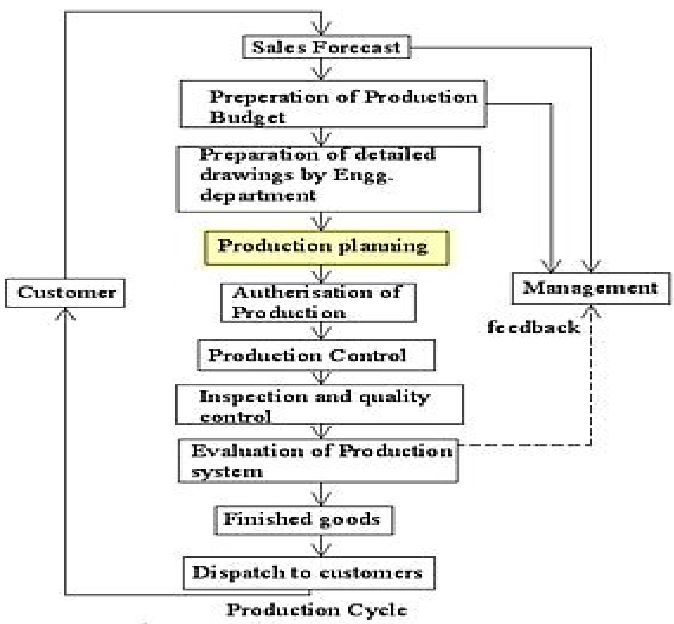


Fig. Role of Production Planning in the Production Cycle.

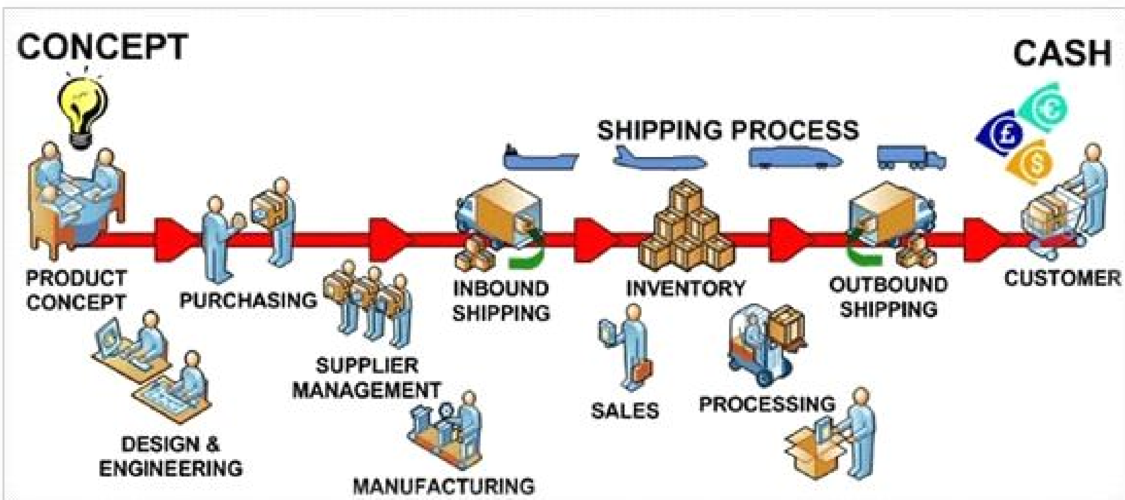


Fig. Raw material to finished goods.

Different types of production planning can be applied:

a) Advanced planning and scheduling

b) Capacity planning

c) Master production schedule

d) Material requirements planning

e) MRP II

f) Scheduling

g) Workflow

RESULT:

VIVA-VOICE:

- What do you mean by production planning in an industrial engineering?
- Define production control.
- Explain the different types of production planning that can be applied in an industrial engineering?
- List the benefits of PPC.
- What are the objectives of production planning in an industrial management?

EXPERIMENT NO-12

OBJECTIVE-To detailed study of Total Quality Management (TQM) in an industrial engineering.

THEORY- Total Quality Management (TQM) describes a management approach to long–term success through customer satisfaction. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work.

Total Quality Management TQM, also known as total productive maintenance, describes a management approach to long-term success through customer satisfaction. In a TQM effort, all members of an organization participate in improving processes, products, services, and the culture in which they work.

Total Quality Management Principles: The 8 Primary Elements of TQM are-

Total quality management can be summarized as a management system for a customer-focused organization that involves all employees in continual improvement. It uses strategy, data, and effective communications to integrate the quality discipline into the culture and activities of the organization. Many of these concepts are present in modern Quality Management Systems, the successor to TQM. Here are the 8 principles of total quality management:

1. Customer-focused

The customer ultimately determines the level of quality. No matter what an organization does to foster quality improvement—training employees, integrating quality into the design process, upgrading computers or software, or buying new measuring tools—the customer determines whether the efforts were worthwhile.

2. Total employee involvement

All employees participate in working toward common goals. Total employee commitment can only be obtained after fear has been driven from the workplace, when empowerment has occurred, and management has provided the proper environment. High-performance work systems integrate continuous improvement efforts with normal business operations. Self-managed work teams are one form of empowerment.

3. Process-centered

A fundamental part of TQM is a focus on process thinking. A process is a series of steps that take inputs from suppliers (internal or external) and transforms them into outputs that are delivered to customers (again, either internal or external). The steps required to carry out the process are defined, and performance measures are continuously monitored in order to detect unexpected variation.

4. Integrated system

Although an organization may consist of many different functional specialties often organized into vertically structured departments, it is the horizontal processes interconnecting these functions that are the focus of TQM.

Micro-processes add up to larger processes, and all processes aggregate into the business processes required for defining and implementing strategy. Everyone must understand the vision, mission, and guiding principles as well as the quality policies, objectives, and critical processes of the organization. Business performance must be monitored and communicated continuously.

An integrated business system may be modeled after the Baldrige National Quality Program criteria and/or incorporate the ISO 9000 standards. Every organization has a unique work culture, and it is virtually impossible to achieve excellence in its products and services unless a good quality culture has been fostered. Thus, an integrated system connects business improvement elements in an attempt to continually improve and exceed the expectations of customers, employees, and other stakeholders.

5. Strategic and systematic approach

A critical part of the management of quality is the strategic and systematic approach to achieving an organization's vision, mission, and goals. This process, called strategic planning or strategic management, includes the formulation of a strategic plan that integrates quality as a core component.

6. Continual improvement

A major thrust of TQM is continual process improvement. Continual improvement drives an organization to be both analytical and creative in finding ways to become more competitive and more effective at meeting stakeholder expectations.

7. Fact-based decision making

In order to know how well an organization is performing, data on performance measures are necessary. TQM requires that an organization continually collect and analyze data in order to improve decision making accuracy, achieve consensus, and allow prediction based on past history.

8. Communications

During times of organizational change, as well as part of day-to-day operation, effective communications plays a large part in maintaining morale and in motivating employees at all levels. Communications involve strategies, method, and timeliness.

All employees participate in working toward common goals. Total employee commitment can only be obtained after fear has been driven from the workplace, when empowerment has occurred, and management has provided the proper environment. High-performance work systems integrate continuous improvement efforts with normal business operations. Self-managed work teams are one form of empowerment.

Benefits of total quality management (TQM):-

Total quality management is a general philosophy of gradually improving the operations of a business. This is done through the application of rigorous process analysis by every involved employee and business partner. TQM is usually applied at the tactical, front-line level, where production, clerical, and low-level managers are deeply involved. There are a number of tools available to assist in a TQM effort, such as:

I) Benchmarking
ii) Failure analysis
iii) Plan-do-check-act (PCDA) cycle
iv) Process management
v) Product design control
vi) Statistical process control

There is some debate regarding which tools fall within the umbrella of TQM, so there are a number of other tools not mentioned here that could be of assistance.

TQM can be implemented successfully in any part of a business, such as:

i) Accounting
ii) Field servicing
iii) Finance
iv) Legal and administration
v) Maintenance
vi) Manufacturing
vii) Materials management
viii) Research and development
ix) Sales and marketing

The advantages of total quality management (TQM) include:

1) Cost reduction. When applied consistently over time, TQM can reduce costs throughout an organization, especially in the areas of scrap, rework, field service, and warranty cost reduction. Since these cost reductions flow straight through to bottom-line profits without any additional costs being incurred, there can be a startling increase in profitability.

2) Customer satisfaction. Since the company has better products and services, and its interactions with customers are relatively error-free, there should be fewer customer complaints. Fewer complaints may also mean that the resources devoted to customer service can be reduced. A higher level of customer satisfaction may also lead to increased market share, as existing customers act on the company's behalf to bring in more customers.

3) Defect reduction. TQM has a strong emphasis on improving quality within a process, rather than inspecting quality into a process. This not only reduces the time needed to fix errors, but makes it less necessary to employ a team of quality assurance personnel.

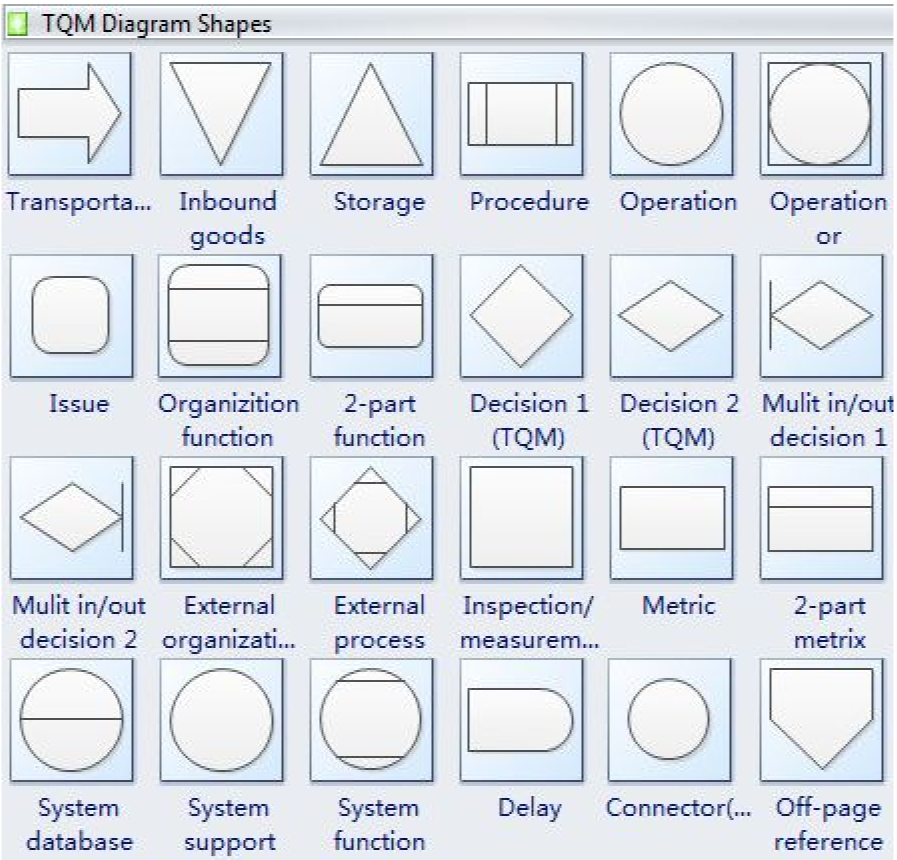
4) Morale. The ongoing and proven success of TQM, and in particular the participation of employees in that success can lead to a noticeable improvement in employee morale, which in turn reduces employee turnover, and therefore reduces the cost of hiring and training new employees.

However, TQM also requires a significant training period for those employees involved in it. Since the training can take people away from their regular work, this can actually have a negative short-term effect on costs. Also, since TQM tends to result in a continuing series of incremental changes, it can generate an adverse reaction from those employees who prefer the current system, or who feel that they may lose their jobs because of it.

TQM works best in an environment where it is strongly supported by management, it is implemented by employee teams, and there is a continual focus on process improvement that prevents errors from occurring.

TQM Diagram Symbols:

With the standard TQM Diagram Symbols, it's easy to create Total Quality Management diagrams for business process re-engineering, continuous improvement, and quality solutions.



RESULT:

VIVA-VOICE:

1. Define the term "TQM" used in an industrial engineering.

2. what are the 8 principles of TQM.

3. What do you mean by TQM diagram symbols.

4. How TQM helps in the development of an industrial management.

5. What are the benefits of total quality management (TQM).

6. How TQM can be implemented successfully in any part of a business.