POORNIMA COLLEGE OF ENGINEERING

ISI-6, RIICO Institutional Area, Sitapura, Jaipur-302022, Rajasthan

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Industrial Engineering-II

Lab Manual

(Lab Code:-8ME7A)

4th Year, 8th Semester

Department of Mechanical Engineering

Session: 2018-19

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MISSION & VISION

INSTITUTE MISSION & VISION

VISION

- To create knowledge based society with scientific temper, team spirit and dignity of labor to face the global competitive challenges

MISSION

- To evolve and develop skill based systems for effective delivery of knowledge so as to equip young professionals with dedication & commitment to excellence in all spheres of life

DEPARTMENT MISSION & VISION

VISION

- To be recognized for quality education in the field of Mechanical Engineering and identified for its innovation & excellence

MISSION

- To provide education that transforms students through rigorous teaching and thought process to fulfill the needs of the society and industry
- To collaborate with leading industry partners and other academic & research institutes around the world to strengthen the education and research ecosystem.
- To prepare students with life-long learning for their career by fostering in them the ethical & technical capabilities pertinent to mechanical & allied engineering.

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RTU SYLLABUS AND MARKING SCHEME

8ME7A: INDUSTRIAL ENGINEERING LAB-II	
Credit: 1.5	**Max. Marks: 75(IA:45, ETE:30)**
0L+0T+3P	**End Term Exam: 3 Hours**

S. No.	**NAME OF EXPERIMENT**
1	Determination of the standard for a given job using stopwatch time-study.
2	Preparation of flow process chart operation process chart and machine charts for an existing setup and development of an improved process.
3	Study of existing layout of a workstation with respect to controls and displays and suggesting improved design from ergonomic viewpoint.
4	To carry out a work sampling study.
5	To conduct process capability study for a machine in the workshop.
6	To design a sampling scheme based on OC curve.
7	To conduct Shewart's experiments on known population.
8	Generation of random numbers for system simulation such as facility planning, job shop scheduling etc.
	Important Note: Study also includes Assembly and disassembly of above systems. It is mandatory for every student to present a term paper. Term paper shall be a group activity. A group shall consist of maximum two students. Final evaluation shall include 30% weight age to term paper. Term paper shall cover study or survey of new technologies in above systems.

EVALUATION SCHEME

I+II Mid Term Examination			**Attendance and performance**			**End Term Examination**			**Total Marks**
Experiment	**Viva**	**Total**	**Attendance**	**Performance**	**Total**	**Experiment**	**Viva**	**Total**	
22	8	30	8	22	30	22	8	30	75

DISTRIBUTION OF MARKS FOR EACH EXPERIMENT

Attendance	**Record**	**Performance**	**Total**
2	3	5	10

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LAB OUTCOME AND ITS MAPPING WITH PO & PSO

LAB OUTCOMES

After completion of this course, students will be able to –

8ME7A.1	To determine time standard for a job using numerical and graphical technique
8ME7A.2	To Construct and implement flow process chart, operation process chart and man machine charts
8ME7A.3	To prepare p, c, and u control charts for attributes from standards or data; and demonstrate how to use the corresponding OC curves
8ME7A.4	To understand the generation of random numbers for system simulation

LO-PO-PSO MAPPING MATRIX OF COURSE

LO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
8ME7A.1	-	-	3	-	-	-	-	-	2	-	-	-	2	2	2
8ME7A.2	-	-	3	-	-	-	-	-	2	-	-	-	2	2	3
8ME7A.3	-	2	-	-	-	-	-	-	-	-	-	-	-	2	2
8ME7A.4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PROGRAM OUTCOMES (POs)

PO1	**Engineering knowledge :** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

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PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	Design, analyze and innovate solutions to technical issues in Thermal, Production and Design Engineering.
PSO2	Exhibit the knowledge and skills in the field of Mechanical & Allied engineering concepts.
PSO3	Apply the knowledge of skills in HVAC&R and Automobile engineering.

RUBRICS FOR LAB

Category	Excellent(4)	Very good (3)	Good (2)	Need to improvement(1)
Scientific Concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.
Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
Drawings/Diagrams	Clear, accurate diagrams are included and make the experiment easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
Calculations	All calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.
Error Analysis	Experimental errors, their possible effects, and ways to reduce errors are discussed.	Experimental errors and their possible effects are discussed.	Experimental errors are mentioned	There is no discussion of errors.

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LAB CONDUCTION PLAN

Total number of Experiment - 8

Total number of turns required - 12

Number of turns required for:-

Experiment Number	Scheduled Week
Experiment -1	Week 1
Experiment -2	Week 2
Experiment -3	Week 3
Experiment -4	Week 4
I Mid Term	**Week 5**
Experiment -5	Week 6
Experiment-6	Week 7
Experiment-7	Week 8
Experiment-8	Week 9
Mini Project/Beyond Syllabus Experiments-	Week 10
Mini Project/Beyond Syllabus Experiments-I	Week 11
II Mid Term	Week 12

DISTRIBUTION OF LAB HOURS

S.No.	Activity	Distribution of Lab Hours	
		Time (180 minute)	Time (120 minute)
1	Attendance	5	5
2	Explanation of Experiment & Logic	30	30
3	Performing the Experiment	60	30
4	File Checking	40	20
5	Viva/Quiz	30	20
6	Solving of Queries	15	15

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LAB ROTAR PLAN

Rotor-1

Ex. No.	Name of Experiment
1.	Determination of the standard for a given job using stopwatch time-study.
2.	Preparation of flow process chart operation process chart and machine charts for an existing setup and development of an improved process.
3.	Study of existing layout of a workstation with respect to controls and displays and suggesting improved design from ergonomic viewpoint.
4.	To carry out a work sampling study.

Rotor-2

Ex. No.	Name of Experiment
5	To conduct process capability study for a machine in the workshop.
6	To design a sampling scheme based on OC curve.
7	To conduct Shewart's experiments on known population.
8	Generation of random numbers for system simulation such as facility planning, job shop scheduling etc.

GENERAL LAB INSTRUCTIONS

DO'S

1. Enter the lab on time and leave at proper time.
2. Feel that practical are essentials to lay the foundation for understanding the subject.
3. Have knowledge of the theoretical background of each experiment.
4. Handling every equipment carefully.
5. Consult your teacher, or your friend who had already done the experiment before entering the lab. This will help you to overcome difficulties while doing the experiments.
6. Turn off the machines before leaving the lab unless a member of lab staff has specifically told you not to do so.
7. Make as many observations/readings as possible. Large number of data will eliminate random errors and systematic errors.
8. Calculations must be done meticulously. For this, the knowledge of using calculators and mathematical tables is essential.
9. If you get wrong result others than the expected one, study your observation thoroughly and find out where you went wrong. Repeat the experiment until you get the correct observation, leading to the correct and expected result.
10. If you notice any problem with machine/ equipment/tool, then please report it to lab staff immediately. Do not attempt to fix the problem yourself.

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DON'TS

1. Don't neglect the importance of practical.
2. Don't be lazy in making observation. Avoid copying someone else's observation.
3. There should not be any distraction. Don't play with your friend or the apparatus while doing the experiment.
4. Don't damage the equipment.
5. Don't touch the moving parts of the machine.
6. Don't play with electric instruments.
7. If you are going to be away from your machine for more than 10 or 15 minutes, switch off before leaving. This is for the security of your experiment and to ensure that others are able to use the lab resources while you are not.
8. No food or soft drink is allowed in the lab or near any of the equipment. Aside from the fact that it leaves a mess and attract pests. If you need to eat or drink, take a break and do so in the canteen.
9. Do not work in a laboratory wearing loose hair, loose clothing or dangling jewellery.
10. Don't wear rings, watches, bracelets or other jewellery that could get could get caught in moving machinery.
11. Do not eat food, drink beverages or chew gum in the laboratory.
12. Don't bring any external material in the lab, except your lab record, copy and books.

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EXPERIMENT NO. 1

Object: To determine standard time for given job using stop watch.

THEORY

We obtain standard work times form

- Direct observation – time studies and sampling
- From observing similar jobs (pre-determined data)
- Reports of those doing the work (trusting their reports)

All involve some form of sampling and generally work measurement requires training for consistency of collection and judgement. People and conditions vary. If performance rating is to be done then subjectivity has to be minimised. Jobs may have short or long cycles of work (two minute to eight hour cycle)

Basic time

When our qualified worker is doing a defined job with standard performance, the time taken to do I (use a stop watch) is the basic time for the job. Operation managers need basic time data for each task so that estimates of completion time can be calculated. the time involved in a large project e.g. build a house can be built estimated if data s available on the time needed to complete each sub-task; foundations, drainage, walls, floors, roof, plastering, electrics, plumbing, glazing etc. if we have time data for moving and marking up a football pitch then we can estimate how many hours It will take to prepare all the football pitches on a public sports ground. Contracts to grounds-keeping firms can be prepared.

Motion study – a noise detailed level of analysis – concentrates on repetitive operations that have short cycle times (3 minutes or less often using film) video to record action. If redundant movement can be eliminated and even three seconds saved, because of the number of repetitions large labour savings are possible.

Standard times

Standard times are a refinement of basic times. The latter reflects performance of a job over a range of conditions. Standard time defines the time required under specific conditions. If incorporates allowances for such, factors as rest relaxation.

A standard time basic time + relaxation allowance + other allowance.

The standard time is ‘ not necessarily the time it will take to actually perform the task but a measured time, normalised to reflect the performance of someone working to a standard.

In incorporates

- Observed times rating of performance
- Reasonable allowances.

It enables units of work to be pressed i.e. as standard minutes or standard hours.

Allowances:

Sever all allowances may be applied to basic time. a relaxation allowance to account for physiological and psychological effects of tasks in certain circumstances and the worker's personal' needs (toilet, washing etc) can be defined as a% t add to basic time.

Other allowances may be agreed to cover attention and effort needed (negligible to very alert m quick , heavy) posture considerations (sitting, standing, crouching, stretching), eye strain and noise, temperature and humidity (hot, ambient, cold), atmosphere (wet, smelly, dust, respirator etc).

Thus we have identified the elements of each. Task and have reliable, sufficient, valid. Observations of the task being done. We have appraised the observed performances and given a rating. Basic times have been calculated by averaging observed time. And we have then added a % allowance to each element to the basic time. We can either apply a performance rating as an adjustment to each element and then total or alternatively we can first total these basic + allowance element times and then apply a performance rating % to the whole.

The result is a standard time for the task/whole job.

Element	Basic time	Relaxation %	Perf %	standard time
1	2.50	+10	110	3.03
2	4.80	+ 5	110	5.81
3	3.60	+15	110	4.55
	Total standard time = 13.39 minutes			

Effort rating: when calculating basic times observers must assess the worker's speed/effort as a % of a normal. There are BSI benchmark rating scales for effort rating. The scales are based on a standard (100%) represented by a normal, trained/skilled, motivated operator working with normal, sustainable effort/speed. Even with such scales as a guideline, the observation and assessment of effort is subjective.

If a worker takes 7.1 minutes to perform a task but does so with exceptional skill/mastery and speed (perhaps to impress the observer) then we can recognise that the operative is working with more than standard/required effort. It may be rated at 110% weighted effort. Thus someone working at 100% standard would take 7.8 minutes to perform the same task. The latter value may be taken as a standard.

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With allowances and effort rating we can recognise the difficulty of employees keeping up the same tempo of work throughout the day. There may be natural interruptions in the work flow beyond the control of the operative or problems requiring supervisory intervention. Staffs have personal need – the toilet, to wash, to rest and have a drink or a meal. A 55 personal allowance amounts to 24 minutes per 8 hours shift. Awkward work with additional fatigue. Factors and poor environmental conditions may raise the allowance % to 10%. In heavy industries such as steel, allowances may be 20% and in engineering 1% can be found.

Example:

The observed time is recorded to be 15 minutes for a fob done by a worker whose rating is 80. Following allowances are recommended by the management –

i) Personal needs allowance - 5% of basic time

ii) Basic fatigue allowance - 2% of basic time

iii) Contingency work allowance - 1% of basic time

iv) Contingency delay allowance- 2% of basic time

Determine basic time, work content and standard time for the job.

From the relationship,

Basic time = observed time x (rating/standard rating)

Example :

Basic time = 15x(80/100) = 12 minutes

So, recommended allowances can be determined as follows –

I) Personal needs allowance = $\frac{5}{100}$ x 12 =3/5 minutes=36 seconds

II) Basic fatigue allowance = $\frac{2}{100}$ x 12= 14.4 seconds

III) Contingency work allowance = $\frac{1}{100}$ x 12= 7.2 seconds

IV) Contingency delay allowance = $\frac{2}{100}$ x 12 = 14.4 seconds

Work content = basic time + relaxation allowance +contingency WA + contingency

= basic time + personal needs A + basic fatigue A + contingency WA

=12 min + 36 sec +14.4 sec + 7.2 sec =12 min 57.6 sec

Standard time = work content ± contingency delay allowance

= 12 min 57.6 sec +14.4 sec

=13 min 12 sec

EXPERIMENT NO. 2

<u>AIM:</u> - Object: Preparation of flow process chart, operation process chart and man-machine charts for an existing setup and development of an improved process.

<u>THEROY</u>: One the general picture of a process has been established, it is possible to ho into greater detail. The first stage is to construct a flow process chart.

A flow process chat is a process chat setting out the sequence of the flow of a predict or a procedure by recording all events under review using the appropriate process chat symbols,

Flow process chat – man type: a flow process chat which record what the worker does

Flow process chart – material type: flow process chat which records how material handled and treated.

Flow process chat – equipment type: a flow process chart which records how the equipment is used.

A flow process chart is a prepared in a manner similar to that to which the outline process chat Is made , but using in addition to the symbols for 'operation ' and 'inspection'

Those for 'transport', delay, storage. Whichever type of flow process chart is being constructed, the same symbols are always used and the chatting procedure is very similar.

(it is customary to use the active voice of verbs for entries on man type charts, and the passive voice on material type and equipment type charts). In fact , it is usual to have one printed chart only for all three types , the heading bearing the word " man/material/ equipment type" the two words not required being deleted.

Flow process chat contains more information than outline process chats because they indicate additionally, storage, delay. And transportation also which represent a major portion of rho product cost. Because of this, it may be desirable to analyse a very in as well as the operations themselves. And in this connection it is worthwhile to mention that like outline process charts, flow process charts also aid in finding out means of combining or eliminating operations and inspections.

Because of its greater detail, the flow process charts does not usually cover as many operations per sheet as may appear on a single outline process chart. it is usual to make a separate chart for each major component of an assembly, so that the amount of handling, delay and storages of each may be independently studied. This means that the flow process chat is usually a single line.

An example of a material type flow process chart constructed to stud what happened when a bus engine was stripped, degreased and cleaned for inspection is given in Figure. This is an actual case recorded at the workshop of a transport authority in developing country. After discussing the principles of flow process charting and the means of using them in the next few pages, we shall go on to consider this example in detail.

When flow process charts are being made regularly, it is convenient to use printed or stencilled sheet similar to that shown in Figure (in charts of this kind the five symbols are usually repeated down the whole length of the appropriate columns. This has not been done in the charts presented in this book, which have been simplified to improve clarity), - this also ensures that the study man does not omit any essential information. In fig. the operation just described on the chart in fig is set down again.

Before we go on to discuss the uses of the flow process chart as means of examining critically the job concerned with a view to developing an improved method, there are some points which must always be remembered in the preparation of process charts. These are important because process charts are the most useful tools in the field of method improvement; whatever techniques may be used later, the making of a process charts always the first step.

1) Charting Is used for recording because it gives a complete picture of what is being done and helps the mind to understand the facts and their relationship to one another.
2) The details which appear on a chart must be obtained from direct observation. Once they remain available for reference and for explaining the situation to others. Charts must not be based on memory but must be repaired as the work is observed (except when a chart is prepared to illustrate a proposed new method).
3) A high standard o neatness and accuracy should be maintained in preparing fair copies of charts constructed for direct observation. The charts will be used in explaining proposals for standardising work or improving methods. And untidy chart will always make a bad impression and may lead to errors.
4) To maintain their value for future reference and to provide as complete information as possible, all charts should carry a heading giving the following information (see fig. 25)
    a. The name of the product, material or equipment, withdrawing numbers code numbers.
    b. The job or process being carried out, clearly states the starting point and the end point, and whether the method is the present or the proposed one.
    c. The location in which the operation is taking place (department, factory, site, etc.)
    d. The chart reference number, sheet number and the total number of sheet
    e. The observer's name and, if desired, that of the person approving the chart.
    f. The date of the study.

g. A key to the symbols used. This is necessary for the benefit of anyone who may study the chart later and who may have been accustomed to using different symbols. It is convenient to show these as part of a table summarising the activities in the present and proposed methods

h. A summary of distance, time and, if desired, cost of labour and material, for comparison of old and new method.

5) Before leaving the chart, check the following points:

a. Have the facts been correctly recorded?

b. Have any over-simplifying assumptions been made (e.g. is the investigation so incomplete as to be inaccurate)?

c. Have all the factor contributing to the process been recorded?

So far we have been concerned only with the record stage. We must now consider the steps necessary to examine critically the data recorded.

CHART No 1	SHEET No 1 OF 1	METHOD:	Original
PRODUCT:	Bus Engines	OPERATIVE (S):	
PROCESS:	Stripping, degreasing and cleaning used engines	LOCATION:	Degreasing shop
		CHARTED BY:	
		APPROVED BY:	DATE:

DISTANCE (m)	SYMBOL	ACTIVITY	TYPE OF ACTIVITY
	▽ 1	In old-engine stores	
	⇨ 1	Picked up engine by crane (electric)	Non-productive
24	⇨ 2	Transported to next crane	"
	⇨ 3	Unloaded to floor	"
	⇨ 4	Picked up by second crane (electric)	"
30	⇨ 5	Transported to stripping bay	"
	⇨ 6	Unloaded to floor	"
	○ 1	Engine stripped	Productive
	○ 2	Main components cleaned and laid out	"
	□ 1	Components inspected for wear; inspection report written	Non-productive
3	⇨ 7	Parts carried to degreasing basket	"
	⇨ 8	Loaded for degreasing by hand-operated crane	"
1.5	⇨ 9	Transported to degreaser	"
	⇨ 10	Unloaded into degreaser	"
	○ 3	Degreased	Productive
	⇨ 11	Lifted out of degreaser by crane	Non-productive
6	⇨ 12	Transported away from degreaser	"
	⇨ 13	Unloaded to ground	"
	D 1	To cool	"
12	⇨ 14	Transported to cleaning benches	"
	○ 4	All parts completely cleaned	Productive
9	⇨ 15	All cleaned parts placed in one box	Non-productive
	D 2	Awaiting transport	"
	⇨ 16	All parts except cylinder block and heads loaded on trolley	"
76	⇨ 17	Transported to engine inspection section	"
	⇨ 18	Parts unloaded and arranged on inspection table	"
	⇨ 19	Cylinder block and head loaded on trolley	"
76	⇨ 20	Transported to engine inspection section	"
	⇨ 21	Unloaded on ground	"
237.5	D 3	Stored temporarily awaiting inspection	"

(Adapted from an original)

Develop the improved method:

There is an old saying that t ask right question is to be halt way towards finding the right answer. This is especially true in method study. From the very brief example of the use of the questioning sequence given above, it will be seen that once the questions have been asked most of them almost answer themselves, once the questions –

- What should be done?
- Where should it be done?

- When should it be done?
- Who should do it?
- How should it be done?

Have been answered. It is the job of the method study man to put his bindings into practice.

The first step in doing is to make a record of the proposed method on a flow process chart, so that it can be compared with the original method and can be checked to make sure that no point has been overlooked. This will also enable a record to be made in the summary of the total numbers of activities taking place under both methods, the savings in distance and time which may be expected to accrue from the change and the possible savings in money which will result. The improved method for example discussed is shown charted in figure.

It will be seen from the summary that there have been considerable reductions in the number of non-productive activities. The number of operation has been reduced from four to three by the elimination of thee unnecessary dealing, and the inspection carried out. Directly after it has also been eliminated. Transport has been reduced from 21 and 15 and distance involved has been carried from 237.5 to 153 metres. A saving of over 37 percent in the level of each engine, In order not to complete this process times of the various activates have not been given; but a study of the two flow process charts will make it evident that a very great saving in the time of operation per engine has been achieved.

FIGURE 13. FLOW PROCESS CHART—MATERIAL TYPE: ENGINE STRIPPING, CLEANING AND DEGREASING

(Original Method)

FLOW PROCESS CHART		MAN/MATERIAL/EQUIPMENT TYPE			
CHART No. *1* SHEET No. *1* OF *1*		SUMMARY			
Subject charted: *Used bus engines*		ACTIVITY	PRESENT	PROPOSED	SAVING
ACTIVITY: *Stripping, cleaning and degreasing prior to inspection*		OPERATION O	*4*		
		TRANSPORT ⇨	*21*		
		DELAY D	*3*		
		INSPECTION □	*1*		
		STORAGE ▽	*1*		
METHOD: PRESENT/~~PROPOSED~~		DISTANCE (m)	*237.5*		
LOCATION: *Degreasing Shop*		TIME *(man-min)*	—	—	—
OPERATOR(S): *A.B.* *C.D.*	CLOCK Nos. *1234* *571*	COST LABOUR MATERIAL	— — —	.	
CHARTED BY: *R.F. Unwalla & K.V. Rao* APPROVED BY: *L.M.B.*	DATE: *11.11.55*	TOTAL	—	—	—

DESCRIPTION	QTY.	DIST-ANCE (m.)	TIME (min)	O	⇨	D	□	▽	REMARKS
Stored in old-engine store								•	
Engine picked up					•				*Electric crane*
Transported to next crane		*24*			•				″ ″
Unloaded to floor					•				
Picked up					•				″ ″
Transported to stripping bay		*30*			•				″ ″
Unloaded to floor					•				
Engine stripped				•					
Main components cleaned and laid out				•					
Components inspected for wear; inspection report written							•		
Parts carried to degreasing basket		*3*			•				
Loaded for degreasing					•				
Transported to degreaser		*1.5*			•				*Hand crane*
Unloaded into degreaser					•				
Degreased				•					
Lifted out of degreaser					•				″ ″
Transported away from degreaser		*6*			•				″ ″
Unloaded to ground					•				
To cool						•			
Transported to cleaning benches		*12*			•				*By hand*
All parts cleaned completely				•					
All cleaned parts placed in one box		*9*			•				*By hand*
Awaiting transport						•			
All parts except cylinder block and heads loaded on trolley					•				
Transported to engine inspection section		*76*			•				*Trolley*
Parts unloaded and arranged on inspection table					•				
Cylinder block and head loaded on trolley					•				
Transported to engine inspection section		*76*			•				*Trolley*
Unloaded to ground					•				
Stored temporarily awaiting inspection						•			
TOTAL		*237.5*		*4*	*21*	*3*	*1*	*1*	

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EXPERIMENT NO. 3

Object: Study of existing layout of a workstation with respect to controls and displays and suggesting improved design from ergonomics viewpoint.

Theory

Workstation design:

The workstation design affects the production rates, efficiency and the accuracy with which an operation can be performed. A workstation not only needs space for the worker the machine there are plenty of other items which also need accommodation. Space requirement and few were factors governing a good workstation design are described below:

A) Space requirement :

a. Space for the workers to stand, sit or turn comfortably to operate the machine.

b. Space for the machine taking into considerations the overhang projections or the over travel of the machine parts, like table of milling machine or planer.

c. Space for the work if just projecting out form the machine like a ling bar fed to a turret lathe.

d. Space for necessary tools and supplies required by the worker.

e. Space for additional attachments accessories or jigs and fixture.

f. Space to load work on and off the machines.

B) Controls, displays and safety requirements:

a. Considerations of the space required for the movement of material handling equipment.

b. Easy access to machine for inspections, lubrication, maintenance and repair.

c. Convenience of making foundation and machine installations.

d. Alike space between one machine and next.

e. Approximate ventilation, lighting and safety arrangements.

Some of the patterns to achieve the effective flow of material through the plant are given in below table

Flow pattern	Characteristics & place of use
	Material enters at one end (x) and leaves at other end (y)

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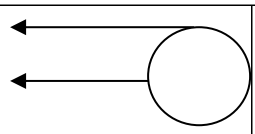
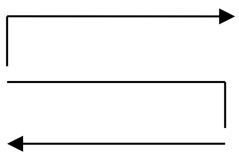
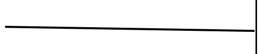
	Resembles line flow and is used where buildings are wave wide
	Performed for rotating handling systems. Raw material enters at X and finished goods come out from Y
	Simplest and best. Raw material entrance and finished goods exit is on the same side
	This system is compact, space has been better utilized and supervision is efficient.

Design of workplace form ergonomic viewpoints

1) Material and tool should be available at the predetermined places and closed to the worker.
2) Tools and materials should preferably by located in order in which they will be used
3) Wherever possible grantee should be employed for the raw material to reach the operator and finished product to be delivered at its destination.
4) The process should not be too automatic to become monotonous and boring for the operator. Under such conditions suitable breaks and rest periods should be provided.
5) The operator should have comfortable posture. The height of seat should be 50 mm below the level of the operator.
6) A worker should be possible to work both while sitting and standing.
7) Worker should be able to operate levers and handles withstand changing body position
8) The work place should have enough illuminating, proper condition of heat, cold and humidity dust noise etc.
9) The back of thee seat not restrict he arm movements

10.A worker should have his choice to sit or stand freely during work.

Suggested work place layout:

Fig showing a work place layout with different area and typical dimensions.

Workplace layout showing different area and typical dimensions (mm)

1) actual working area = It is most convenient area for working
2) Normal working area = it is within the easy reach of the operator
3) Maximum working area = it is accessible with full area switch

Result :

We studied the existing layout and improved design from ergonomic viewpoint.

EXPERIMENT NO. 4

OBJECT : To carry out a work sampling study.

<u>Theory</u>

Work sampling :

Work sampling is also called as activity sampling or ratio delay study. It is a work measurement technique in which a large number of instantaneous observations are made at renders inverse over a specified period of time of a group of warriers, machines and processes. Each observation record what is happening it that instant and the percent of observations recorded for a particular.

It can also be defined as a method of tending the percentage occurrence of a certain activity by statically sampling and random observations.

Mr. Tippet defined work sampling as a method of finding the ratio of delay and work element to the total process time by random observations.

Work sampling thus involves the estimation of the proportions of time devoted to a given type of activity over a certain period of time by means of intermittent, randomly spaced instantaneous observations.

Work sampling can tell for how much time a person works and how much time he expends for his personal needs and how much time he remains idle, to explain it more clearly, let us consider an example of a machine shop with a view to know how much time the operator has worked. The analyst takes 20 rounds of the machine shop in a day at random intervals, observes the operator and finds that:

12 times he was working on a machine –

4 times he was setting up cleaning the machine

2 times he was not doing anything

2 times he attended his personal needs.

It shows that the worker actually worked for 60% of the time on the machine and for 10% if total time he was idle, etc.

Principle of work sampling: work sampling relies upon statistical theory of sampling and probability theory. Normal frequency distribution and confidence level are associated very much with work sampling.

Statistical theory of sampling explains that adequate random samples of observations spread over sufficient period of time can construct an accurate posture of the actual situation in the system. Approximately 500 observations produce fairly reliable results and results obtained through 3000 or more observations are very accurate.

Work sampling procedure:

The work sampling procedure can be divided into the following three phases

A) Preparing for the work sampling

   a. Decide the main objective of the study.
   b. Obtain – the approval of the supervisor of the department in which work sampling is to be performed.
   c. Based upon the , establish the quantitative measure of activity.
   d. Selection and training of personnel.
   e. Making a detailed plan for taking-observations.

B) Performing work sampling.

   a. Classify the different categories of activities (element) to be studied.

      Depending upon the and the end use, one activity can be classified into certain elements. For example, a study is carried out in a machine shop to analyse the total productive time which may consist of set up time, loading time, actual operation etc.

   b. Design the observation forms.
   c. Determine the number of days or shifts required for study.
   d. Develop properly randomised times of observations.

Before actual observation are taken, the following steps are important from the initial planning

Defining and decide the areas to be studied and the time limits.

Decide the number of locations to be observed.

Distance between two operators.

Form the random tables, take the random times at which the observation trip is to be made. Enter these times in the observation sheet. The number of observations to be taken (sample size) are already – calculated – with the help of formula for the desired accuracy.

e. Observing activity and recording data.

f. Summarising the data.

C) Evaluating and presenting results of work sampling :

a. Presenting and analysing data.

b. Planning for future studies.

In order to evaluate the reliability of data, control limits are used. Control limits have been found very useful. The control chart in work sampling enables the analyst to plot the daily or cumulative results of sampling. If a point falls outside the control limits, this indicates that some unusual or abnormal conditions are present during study.

Control limits = $\bar{p} \pm 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

Where, $\bar{p}$ = average probability

N = sample size

Determination of sample size, the work sampling technique is similar to sampling technique used in statistical quality control where conclusion about the defective items P in a large number of items (in a lot) is to be drawn after observing the proportion defective P in a suitably selected sample size ‘n’ from the lot.

The formula for determining the number of observations required is given by

P.S. = K σ P

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

Where, K= a factor, the value of which depends on the desired confidence level. For example, for 95% confidence level, K 1.96.

P = % occurrence of the activity (working or idle) being measured in fraction.

S = error (accuracy required) in fraction

N = number of observations required for the desired confidence level and margin of error.

In order to find out the value of n, p is initially assumed or estimated taking trial observations during the study. V Using the estimated value of P value of ‘n’ is determined satisfying the confidence level and accuracy constraint.

The process of finding out the value of ‘n’ can be explained through the following example:

Example:

Work sampling study was conducted to determine the percentage of idle time, of and automatic machine action calculate the number of observations necessary to obtain the desired results assuming confidence level to 95% and the error (accuracy required) to be ±5%

In order to estimate the value of ‘P’, a trial study was conducted consisting of 1000 random observations. 50 observations showed that the machine was idle. Hence the % of idle time = 25% i.e. P0.25.

Substituting the value of P in the formula, we get

P.S. = $k\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$ Now, P = 0, S = 0.05, K = 1.96

i.e. $0.25 \times 0.05 = 1.96\sqrt{\frac{0.25(1-0.25)}{n}}$

i.e. n= 1609.92= 4610

The number of observations

And also he computed with the help of alignment charts or the tab of uomngralns these are prepared for 95% confidence level and ±5 % accuracy

If it is desired, 99 % confidence level with 2 % accuracy should be attained, then 99 % confidence level is approximately 3 sigma limits, hence the formula becomes

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

It is advised to recalculate ‘n’ at regular intervals.

After the stilly is completed, a calculation can be made to determine whether the results are within the desired accuracy or not. This can be done by calculating ‘S’ in the formula instead of ‘n’

Suppose the final results of a study were as below:

Number of times machine working = 3 000

Number of times it is idle = 1000

Then, P == $\frac{1000}{3000+1000}$ = 0.25, a=3000 + 1000

S.P. = $1.96\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$

i.e. S = 0.0530 i.e. 5.30 %

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Which is nearly equal to 5% the required accuracy? This would mean that we are 95% confident that the machine was idle 25% of total time. The accuracy 5.3 8 % means that the results were correct within 5.30 % x 25% = ±1.325%.

Recording the observations: fig shows the work sampling record sheet. The analysis of the result can be calculated readily on the record sheet. It is possible to find out the percentage effective tie compared with that of delays to analyze the reasons for ineffective time and to ascertain the percentage of time spent by a worker, group of workers or a machine on a given work element.

Date		Observer	Study no.	
Number of observations : 110			Total	Percentage
Machine running		IIIIHIIII HII IIIIHIIII HII IIIIHIIII HII IIIIHIIII HII IIIIHIIII HII IIIIHIIII H	87	79
Machine Idle	Repairs	IIIIHII	8	7.25
	Supplies	IIIIHI	7	6.35
	Personal	Ll	2	1.80
	Idle	IIIIH	6	5.40

Fig : work sampling record sheet

Applications of work sampling:

Work sampling is a relatively simple technique which can be used advantageously in wide variety of situations, such as a manufacturing, servicing and office operations.

Some uses of work sampling are:

1. Estimation of unavoidable delay time as the basis for establishing allowances to compute standard time.
2. Estimation of the percentage of time consumed by various job activities on the part of supervisor, engineer, inspector, office personnel etc.
3. Estimation of percentage utilization of machine tools. Cranes, ,in the heavy machine shop, fork lift truck in a warehouse which will be helpful in the economic analysis of ht equipments needed.

4. Compare the efficiency of two departments.
5. To provide more equitable distribution of work in a group.
6. Toa id in job evaluation.
7. For appraisal of safety performance.
8. For appraisal of organizational efficiency.
9. To determine the nature and extent of 'cycles' and 'peak load' variations in observable activity.

Advantages of work sampling:

1. The activities which are impractical or costly to measure by time study can be measured readily by work sampling.
2. A single observer can make work sampling study of several operators or machines.
3. The cost and time involved in work sampling study is quite less as compared to that required for continuous time study.
4. A work sampling study may be interrupted at any time without affecting the results.
5. There is less chance of obtaining misleading results as the operators are not under close observations.
6. Work sampling studies are less tedious and cause less fatigue to observer.
7. It is not necessary to use trained time study observer.
8. Stop watch or other timing devices are not required for work sampling studies.

Disadvantages:

1) Work sampling does not permit finer breakdown of activities and delays. It can't provide much detailed information.
2) It is economical and practicable only when a large number of operators are observed or for studying operators or machines located over wide areas.
3) In certain kinds of work sampling studies, the record of method used by the operators is not made. Therefore, whenever a method change occurs in any element any entirely new study must be made.
4) Management and workers may not understand statistical work sampling as readily as they do time study.

EXPERIMENT NO. 5

Object: to conduct process capability study for a machine in the workshop.

Theory

Process capability:

Process capability may be defined as the "minimum spread of a specific measurement variation which will include 99.7 % of the measurements from the given process'. In other words, process capability 6' since, 6G is taken as a measure of spread of the process, which is also called natural tolerance; process capability study is carried out to measure the ability of the process to meet the specified tolerances.

By this study, it becomes possible to know the percentage of the products which will be produced within ±3 limits on either side of the mean X

A process capability analysis consist

1. Measuring the process capability to find out either the process is inherently capable of meeting the specified tolerance limits.
2. Discovering why a process capable is falling to meet specifications.

When making the study it is important to minimize the effect of factors such as unnatural material variation, process adjustment etc. hence homogeneous material should be used , no process adjustments should be made during the study, trained operators should be allowed to be perform the work. A number of samples are then taken over a period of time . each sample consists of a consecutively made pieces.

The analysis is done in the following manner.

1. Calculate the average X and range T of each sample.
2. Calculate the grand average X, these measures the…..
3. Calculate control limits and plot X and R charges

This measures the stability of the process, i.e. the extent to which is changes with time.

4. Calculate the process capability $6a^2=6\frac{\bar{g}}{d2}$

The measures the piece to piece variability of the process.

Possible relationship of a process in control to upper and lower specification limits.

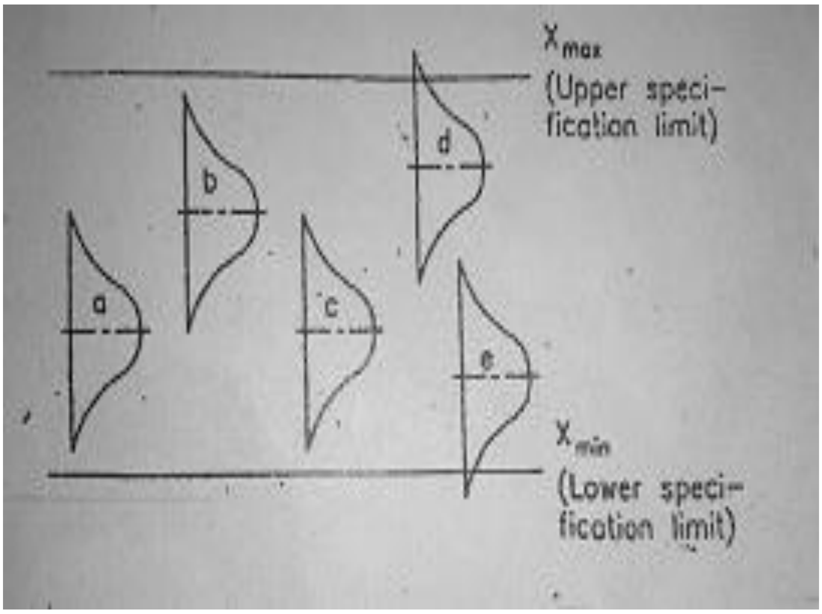
When a controlled process must meet two specification limits on individual values, upper specification limit and lower specification limits, the possible situations may be grouped int these general classes as described below.

1. $(X_{max}-X_{min})>60^o$

   Where X_{max} = upper specification limit

   X_{min}= lower specification limit

In this case the spread of the process ($6\sigma^2$ is considerably less than the difference between the upper specification limit and lower specification limit. The first situation is shown in fig.



The frequency curves a, b, c, d and e shows various positions in which the process might be centered.

Conclusion:

i) With any position a, b, c, practically all the products manufactured will meet specifications as the process stays in control.

ii) It may be considered economically advisable to permit X to go out of control if it does not go too far, i.e. the distribution may be allowed to move between positions b and c. this may avoid the cost of frequent machine setups and the delay due to hunting for assignable causes of variation that will not be responsible for unsatisfactory product.

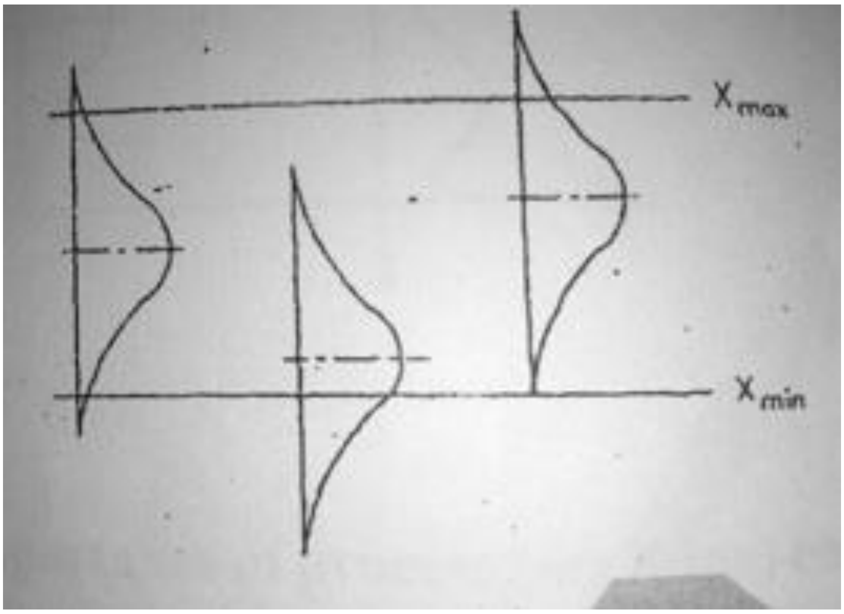
iii) If $(X_{max}-X_{min})/6\sigma$ ratio is considerably large, frequency of control chart may ve reduced.

iv) If there is an economic advantage to be gained by tightening the specification limits, it may be considered.

With the process in position d, some product will fall above the upper specification limit in position c some product will fall below the lower specification limit. In both cases, it is absolutely necessary to change the centering of the process, bringing it close to position a.

2. $(X_{max} - X_{min}) < 6\sigma'$. In this case the spread of the process ($6\sigma'$) to appreciably greater than the difference between the specifications limits as shown in fig.

   Conclusion: in this type of situation defective parts will always be there, therefore, the remedy will be



i) Increase the tolerance.

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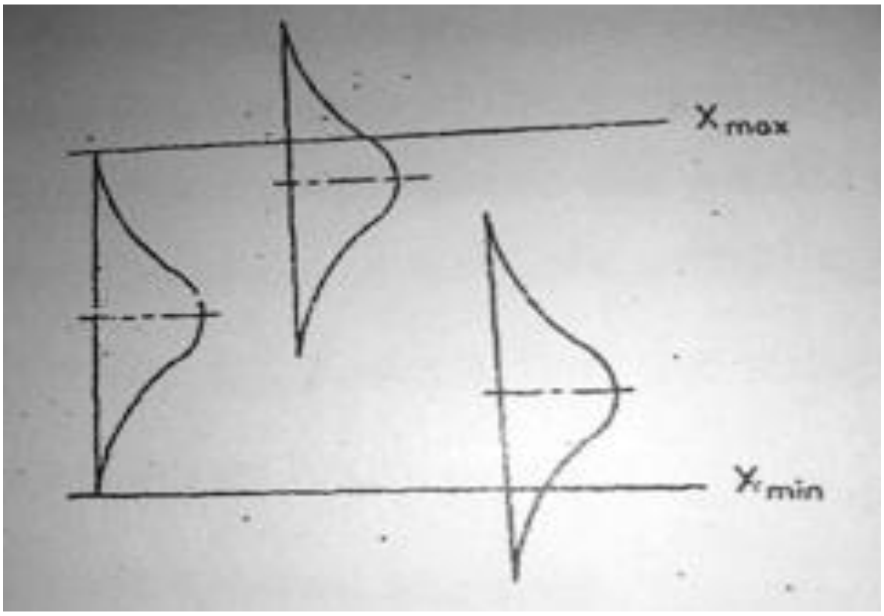
ii) Reduce the dispersion, by making fundamental changes in the production methods, machines used etc.

iii) Suffer and sort out the defectives, if it is economical than making the fundamental changes, (iv) it is still important to maintain catering of the process.

3. $(X_{max}-X_{min}) = 6\ \sigma^2$



Conclusion :

i) It is necessary to maintain centering of process.

ii) It is advisable to increase tolerance if they are tighter than is really necessary.

iii) Reduce dispersion if it is economical.

Importance of process (machine) capability study to solving quality problems:

The information obtained form process capability it of great importance in solving quality problems as follows:-

1. The design engineer, knowing the capability of the process and the available equipment, has more rational basis while setting the specifications.
2. The planning engineer can assign the jobs with more tight tolerances to the most capable machines and that with wider tolerance to the less precise machines.
3. The tool designer can spot the places there tooling improvement must be made to maintain the process capability.
4. The capability information helps the foreman to decide which machines may require overhaul.
5. The machine set up learns which machine requires the most attention to set up and which one needs only normal care

6. The machine operates and inspector can decide which machines need closest with in production.
7. While purchasing tool provides a means to actual performance of equipment with manufacturing claim.

EXPERIMENT NO. 6

Object: to design a sampling scheme based on OC curves.

Theory

The operating curves for an attribute sampling plan is a graph of fraction defectives in a lot against the probability of acceptance. For any fraction defective p' in a submitted lot, the OC curve shows the provability P_n that such a lot will be accepted by the sampling plan. In a single sampling plan three parameters are specified.

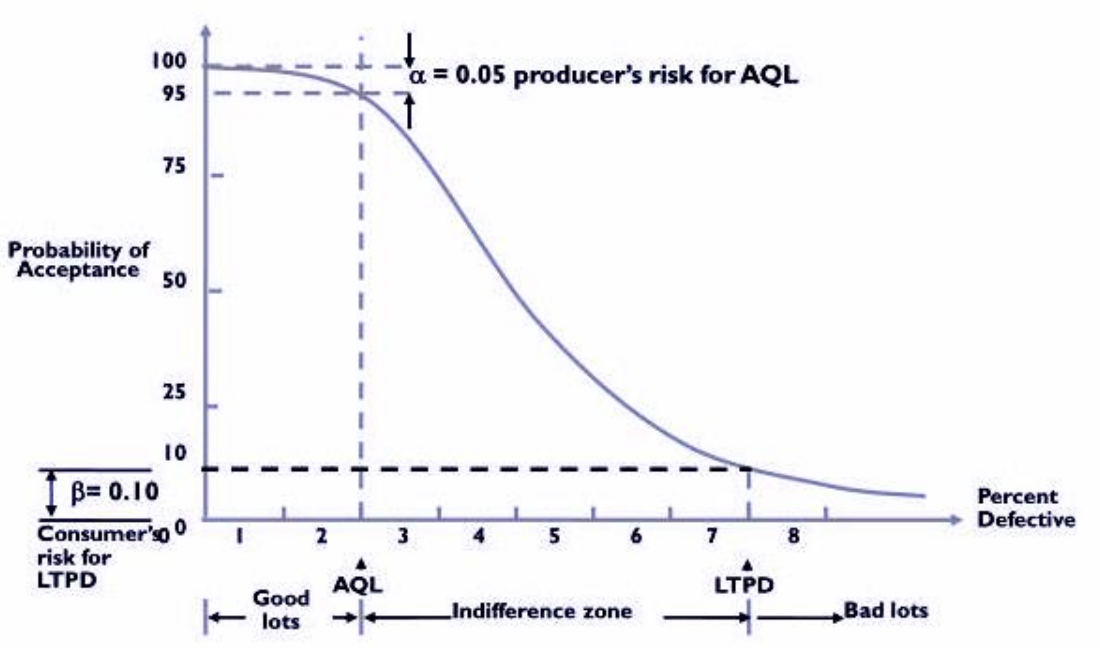
N = lot size from which the samples are down

n = sample size

C = acceptance number.

If the sampling plan is: N = 100, n =5 , C = 2

It means take a random sample of 5 from a lot of 100, if the sample contains more than x defectives, reject the lot otherwise accept the lot. By changing the parameters N, n and C different sampling plans can be obtained. For different sampling plans the OC curves will differ. To construct an OC curve, we should know the mathematical probability of accepting lots with varying percent defectives. This can be obtained from the table of Poisson's distribution (given in Appendix)



1. Acceptable quality level (AQL): it represents the maximum proportion of defectives which the consumer finds definitely acceptable. AQL can also be defined as the maximum percent defectives that for the purpose of sampling inspection can be considered as satisfactory as a process average. It is the fraction defective that can be tolerated without any serious effect upon further procession or on customer or on customer relations.

   As an AQL, is an acceptable quality level, the probability of acceptance for an AQL, lot should be high. In fact the producer's safe point is termed as AQL.

2. Reject able quality level (RQL). It is also called as lot tolerance percent defective (LTPI). This is a definition of unsatisfactory quality. It represents the preparation of defectives which the consumer funds definitely unacceptable. As RQL is an unacceptable quality level, the probability of acceptance for an RQL lot should be low. The probability of accepting a lot at RQL level represents consumer's risk.

3. Indifference quality level (IQL). This is a quality level somewhere between the AQL and RQL. It is frequently defined as the quality level having a probability of acceptance of 0.50 for a given sampling plan.

4. Average outgoing quality (AOQ). It represents the average % defective in the outgoing products after inspection, including all accepted and all rejected lots which have been 100% inspected and defectives replaced by non-defectives.

So, for a given fraction defectives, the lot accepted as a result of first sampling in section will have a fraction defective P', the rejected lots are subjected to 100% inspection and rectification (defective articles are either replaced or corrected) the AOQ will therefore he less than P^o).

Let

n= sample size,

N= lot size,

K = number of lots submitted for acceptance

P' = fraction defective.

P_o = probability of acceptance

$(1-P_o)$ = probability of rejection.

Then, the proportion of the lots accepted $=p_o k$

Proportion of the lots rejected = $k(1-P_o)$

Which are subjected to 100% inspection and rectification?

Number of defects originally present in k lots = $k.N.p^o$

Number of defectives in the outgoing lots

$=p'.\ p_e.k(N-n)$

Total number of defectives

$P'P_o.k(N-n) + k(n)(0)$

$$4OQ = \frac{k.Pa.P'(N-n)+k(n)(o)}{k.N}$$

$$= P_a P' \left\{\frac{N-n}{N}\right\}$$

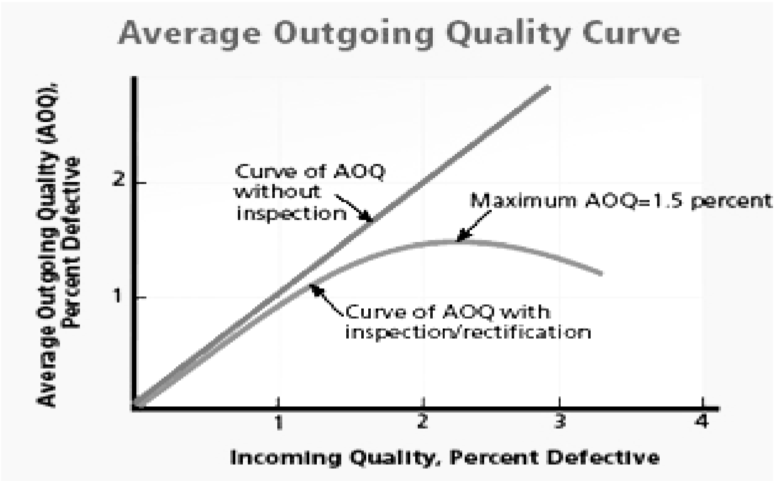
If the sample size is much less as compared to lot size.

$AOQ = P_a p'$

The calculation of average outgoing quality gives the expected quality in the long run. Over a short period, the outgoing quality may be better or worse than the long – nm average.

Any acceptance/ rectification plan guarantees that regardless of the incurring quality submitted, the outgoing quality in the long run will not be worse than the AOQL.

For acceptance / rejection scheme the OC curve is used but for rectification scheme the curve of AOQ plotted against P' is used :



The time AOQ = p' represents what would happen if there were no inspection. For any given values of n and c, the AOQ curve falls below the line AOq = P'. As p' increases, the proportion of rectified lots increases and hence the AOQ curve falls below the line.

AOQ = p'

Characteristics of OC curve:

1. The operating characteristic (OC) curve of an acceptance sampling plan shows the ability of the plan to distinguish between good lots and bad lots.
2. Sampling acceptance plans with same percent samples gives very different quality protection. For sample, the curves (fig. 46.12) show that lots which are 4% defective will be accepted 81% of the time using a 10% sample form a lot of 100,42% of the time using a 10% sample from a lot o 200, and less than 3% of the time by a 10% sample from a lot of 1000, assuming an acceptance number of zero in all cases.

   Obviously a producer making a product 4% defective would have a strong motive for trying to have his product inspected in lots of 50 rather than in lots of 100.
3. Fixed sample size tends towards constant quality protection. It is the absolute size of the sample rather than its relative size that determines the quality protection given by an acceptance sampling plan.

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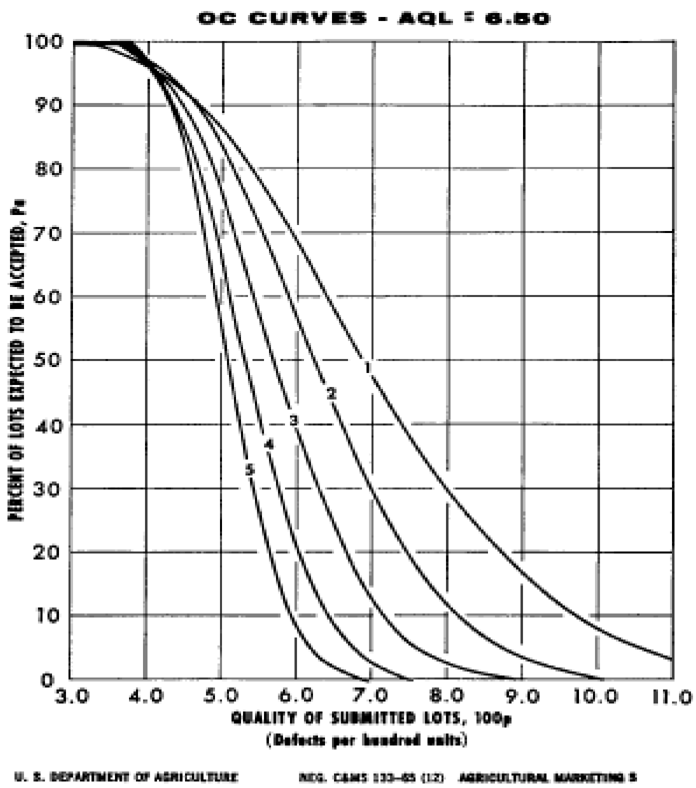
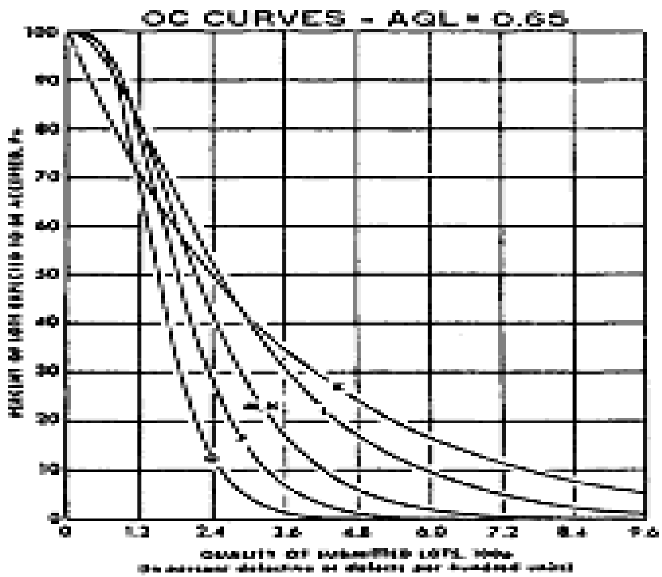


4. The OC curves of plan with acceptance numbers greater than zero are superior to those of comparable plans with acceptance number of zero.
5. With fixed value of N, and can, larger the value of n. the better is the ability of the plan to discriminate between good and bad lots. Fig. 13 illustrates this point.



6. The larger the sample size and acceptance number, the steeper the slope of the OC curve. Fig. shows that the larger sample size which protects the consumer against the acceptance of relatively bad lots also give better protection to the producer against rejection of relatively good lots.

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EXPERIMENT NO. 7

Objective: To conduct shewart's experiments on known population.

Theory

Control charts, also known as Shewhart charts (after Walter A. Shewhart) or process-behavior charts, are a statistical process control tool used to determine if a manufacturing or business process is in a state of control. It is more appropriate to say that the control charts are the graphical device for Statistical Process Monitoring (SPM). Traditional control charts are mostly designed to monitor process parameters when underlying form of the process distributions are known. However, more advanced techniques are available in the 21st century where incoming data streaming can-be monitored even without any knowledge of the underlying process distributions. Distribution-free control charts are becoming increasingly popular.

Overview

If analysis of the control chart indicates that the process is currently under control (i.e., is stable, with variation only coming from sources common to the process), then no corrections or changes to process control parameters are needed or desired. In addition, data from the process can be used to predict the future performance of the process. If the chart indicates that the monitored process is not in control, analysis of the chart can help determine the sources of variation, as this will result in degraded process performance. A process that is stable but operating outside desired (specification) limits (e.g., scrap rates may be in statistical control but above desired limits) needs to be improved through a deliberate effort to understand the causes of current performance and fundamentally improve the process.

The control chart is one of the seven basic tools of quality control. Typically control charts are used for time-series data, though they can be used for data that have logical comparability (i.e. you want to compare samples that were taken all at the same time, or the performance of different individuals); however the type of chart used to do this requires consideration.

Chart details

A control chart consists of:

- Points representing a statistic (e.g., a mean, range, proportion) of measurements of a quality characteristic in samples taken from the process at different times (i.e., the data)

- The mean of this statistic using all the samples is calculated (e.g., the mean of the means, mean of the ranges, mean of the proportions)
- A center line is drawn at the value of the mean of the statistic
- The standard deviation (e.g., sqrt(variance) of the mean) of the statistic is also calculated using all the samples
- Upper and lower control limits (sometimes called "natural process limits") that indicate the threshold at which the process output is considered statistically 'unlikely' and are drawn typically at 3 standard deviations from the center line

The chart may have other optional features, including:

- Upper and lower warning or control limits, drawn as separate lines, typically two standard deviations above and below the center line
- Division into zones, with the addition of rules governing frequencies of observations in each zone
- Annotation with events of interest, as determined by the Quality Engineer in charge of the process' quality
- Action on special causes

(n.b., there are several rule sets for detection of signal; this is just one set. The rule set should be clearly stated.)

1. Any point outside the control limits
2. A Run of 7 Points all above or all below the central line - Stop the production

- Quarantine and 100% check
- Adjust Process.
- Check 5 Consecutive samples
- Continue The Process.

3. A Run of 7 Point Up or Down - Instruction as above

Chart usage

If the process is in control (and the process statistic is normal), 99.7300% of all the points will fall between the control limits. Any observations outside the limits, or systematic patterns within, suggest the introduction of a new (and likely unanticipated) source of variation, known as a special-cause variation. Since increased variation means increased quality costs, a control chart "signaling" the presence of a special-cause requires immediate investigation.

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This makes the control limits very important decision aids. The control limits provide information about the process behavior and have no intrinsic relationship to any specification targets or engineering tolerance. In practice, the process mean (and hence the centre line) may not coincide with the specified value (or target) of the quality characteristic because the process design simply cannot deliver the process characteristic at the desired level.

Control charts limit specification limits or targets because of the tendency of those involved with the process (e.g., machine operators) to focus on performing to specification when in fact the least-cost course of action is to keep process variation as low as possible. Attempting to make a process whose natural centre is not the same as the target perform to target specification increases process variability and increases costs significantly and is the cause of much inefficiency in operations. Process capability studies do examine the relationship between the natural process limits (the control limits) and specifications, however.

The purpose of control charts is to allow simple detection of events that are indicative of actual process change. This simple decision can be difficult where the process characteristic is continuously varying; the control chart provides statistically objective criteria of change. When change is detected and considered good its cause should be identified and possibly become the new way of working, where the change is bad then its cause should be identified and eliminated.

The purpose in adding warning limits or subdividing the control chart into zones is to provide early notification if something is amiss. Instead of immediately launching a process improvement effort to determine whether special causes are present, the Quality Engineer may temporarily increase the rate at which samples are taken from the process output until it is clear that the process is truly in control. Note that with three-sigma limits, common-cause variations result in signals less than once out of every twenty-two points for skewed processes and about once out of every three hundred seventy (1/370.4) points for normally distributed processes. The two-sigma warning levels will be reached about once for every twenty-two (1/21.98) plotted points in normally distributed data. (For example, the means of sufficiently large samples drawn from practically any underlying distribution whose variance exists are normally distributed, according to the Central Limit Theorem.)

Types of chart

Chart	Process observation	Process observations relationships	Process observations type	Size of shift to detect
$\bar{x}$ and R chart	Quality characteristic measurement within one subgroup	Independent	Variables	Large ($\geq 1.5\sigma$)
$\bar{x}$ and s chart	Quality characteristic measurement within one subgroup	Independent	Variables	Large ($\geq 1.5\sigma$)
Shewhart individuals control chart (ImR chart or XmR chart)	Quality characteristic measurement for one observation	Independent	Variables†	Large ($\geq 1.5\sigma$)
Three-way chart	Quality characteristic measurement within one subgroup	Independent	Variables	Large ($\geq 1.5\sigma$)
p-chart	Fraction nonconforming within one subgroup	Independent	Attributes†	Large ($\geq 1.5\sigma$)
np-chart	Number nonconforming within one subgroup	Independent	Attributes†	Large ($\geq 1.5\sigma$)
c-chart	Number of nonconformances within one subgroup	Independent	Attributes†	Large ($\geq 1.5\sigma$)
u-chart	Nonconformances per unit within one subgroup	Independent	Attributes†	Large ($\geq 1.5\sigma$)
EWMA chart	Exponentially weighted moving average of quality characteristic measurement within one subgroup	Independent	Attributes or variables	Small ($< 1.5\sigma$)
CUSUM chart	Cumulative sum of quality characteristic measurement within one subgroup	Independent	Attributes or variables	Small ($< 1.5\sigma$)
Time series model	Quality characteristic measurement within one subgroup	Autocorrelated	Attributes or variables	N/A
Regression control chart	Quality characteristic measurement within one subgroup	Dependent of process control variables	Variables	Large ($\geq 1.5\sigma$)

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EXPERIMENT NO. 8

Objective: Generation of random numbers for system simulation such as facility planning, job shop scheduling etc.

APPARATUS REQUIRED:

1. Electric toaster – 1no (* which can toast the bread slice only one side)

2. Pack of sliced bread – 1no

3. Stop watches – 2 nos

4. Bread boxes – 2 nos

THEORY: A multiple activity chart is a chart on which the activities of more than one subject (worker, machine or item of equipment) are each recorded on a common time scale to show their inter-relationship. By using separative vertical columns or bars to represent the activities of different operatives or machines against a common time scale, the chart shows very clearly periods of idleness on the part of any of the subjects during the process. A study of the chart often makes it possible to rearrange these activities so that such ineffective time is reduced.

The multiple activity chart is extremely useful in organizing teams of operatives on mass-production work and also on the maintenance work when expensive plant can not be allowed to remain idle longer than is absolutely necessary. It can also be used to determine the number of machines which an operative or operatives should be able to look after.

In making a chart, the activities of the different operatives or of the different operatives and machines are recorded in terms of working time and idle time. Thesetimes may be recorded by ordinary wristwatch or by stopwatch, according to the durationof the various periods of work and idleness (i.e whether they are a matter of minutes orseconds). Extreme accuracy is not required but timing must be accurate enough for thechart to be effective. The times are then plotted in their respective columns shown in the figure.

The following graphical representations (or symbols) may be used to show the working time and idle time of either man or machine.

PROCEDURE:

PRESENT METHOD:

1. Connect the electric toaster to the required electric power supply.

2. Set the temperature of timing level at any desired value by rotating the corresponding knob.

3. The operator places two slices of bread with both hands in either side of toaster and keep the pop up knob in bottom most position.

4. The time is measured and recorded for the above activity of operator.

5. As soon as the knob is kept in the bottom most position, the toaster toasts the twoslices of bread simultaneously.

6. As the toaster is an automatic popup type electric toaster, the two slices of the breadwill popup at the end of proper toasting.

7. The time is again measured and recorded for the above activity of the toaster.

8. Repeat the steps from 3 to 7 for toasting the second side of the two slices. Measure the unloading and loading times of operator for the second side toasting.

9. Unload both the slices which are toasted both the sides.

10. Load the third slice for toasting.

11. Follow the same old procedure. Measure the timings and thus complete the toasting of third slice both the sides leaving the other compartment of the toaster unutilized. This method has to be improved because of non-utilization of the second compartment while toasting the 3rd slice in the first compartment.

12. Draw the man-machine chart corresponding to the above subject as per the sample illustrated.

13. Calculate the percentage utilization of operator and toaster compartments 1 & 2.

IMPROVED METHOD:

1. Method of toasting, loading & unloading is same. But the sequence of steps in toasting the 2 sides of 3 slices is different in this improved method.

2. Place the two slices in two compartments. One side of each slice gets toasted.

3. Now unload the slice –2 and keep it in the tray and load slice 3. Unload & load the slice 1 for other side toasting.

4. After toasting unload the slice 1 which is toasted both the sides. Then unload & load slice 3 for toasting second side. Load slice 2 in first compartment for 2nd side toasting.

5. Thus after finishing the complete toasting of 3 slices, calculations have to be done.

6. Draw the man-machine chart corresponding to the above subject as per the sample illustrated.

7. Calculate the percentage utilization of operator and toaster compartments 1 & 2.