UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Environmental Engineering.** Subject Code: **CE-701**
Year: **4th Year** Semester: **Seventh**

Module No.	Topics	Planned Lectures(H)
1.	**Water Demand**	**3 H**
	1. Water demands; Per capita demand; Variations in demand	1 H
	2. Factors affecting demand;Design period;	1 H
	3. Population forecasting	1 H
2.	**Sources of Water**	**2 H**
	1. Surface water sources;	1H
	2. ground water sources	1H
3.	**Water Quality**	**2 H**
	1. Impurities in water; Water quality parameters	1 H
	2. Standards for potable water	1 H
4.	**Conveyance of water**	**2H**
	1. Hydraulic design of pressurepipes	2H
5.	**Water Treatment**	**8 H**
	1. Typical flow chart for surface and ground water treatments;	2H
	2. Aeration, Plain sedimentation,	2H
	3.Sedimentation with coagulation, Water Softening,	2 H
	4Filtration,Disinfection	2 H
6.	**Water Distribution**	**4H**
	1. Analysis of distribution network	2H
	2. Storage and distribution reservoirs; Capacity of reservoirs	2 H
7.	**Sewage and Drainage**	**3 H**
	1. Definition of Common Terms,	1H
	2. Quantity estimation for sanitary sewage and storm sewage	2H
8.	**Sewer Design**	**3 H**
	1. Hydraulic design of sewers	1H
	2. Partial flow diagrams and Nomograms	2H
9	**Wastewater Characteristics**	**3 H**

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Environmental Engineering** Subject Code: **CE-701**
Year: **4th Year** Semester: **7th**

	Physical, chemical and biological characteristics	1 H
	DO, BOD and COD	2 H
10	**Wastewater Treatment**	**6 H**
	Typical flow chart for wastewater treatment;	2 H
	Primary Treatments; Secondary Treatments:	2 H
	Activated Sludge Process, Trickling Filter Process, Septic Tank	2 H
TOTAL HOUR REQUIRED=36		

Faculty In-Charge HOD, CE

Assignment :

Module : 1

1. What is Per Capita Demand? Factors effecting per capita demand?
2. Define Design period? Factors effecting design period.
3. Discuss in brief about population forecast concluding any three methods.
4. Practice problems of population forecast.

Module :2

1. Discuss about surface sources of water supplies in brief.
2. Write about various kinds of Dam.
3. Discuss about the storage capacity of reservoir .
4. Write short notes on Catchment yield & Reservoir Yield.
5. Discuss about reservoir sedimentation and its control.
6. Practice problem over trap efficiency and capacity inflow.
7. Discuss about reservoir loss.
8. Write about Geological factors governing the occurrence of groundwater.
9. Discuss about the types of aquifers and their types.
10. Write short notes on : (i) Infiltration gallery, (ii) Infiltration wells

(iii) Springs (iv) Wells.

Module :3

1. Discuss about the steps involved of purification of water.

2. Practice problem on sedimentation tank.

Module :4

1. A pipeline 0.6 m diameter is 1.5 km long . To augment the discharge, another pipeline of the same diameter is introduced parallel to the first in the second half of its length. Find the increase in discharge if f = 0.04 and head at the inlet is 30 m.

2. Water flows in a 80 mm pipe at Reynolds number 80,000. The pipe is estimated to have an equivalent sand grain roughness of size 0.16 mm . Determine the head loss expected in 500 m length of the pipe. How much head loss would be expected if this pipe was smooth? Take $\mu = 10^{-6} m^2/sec$

Module :5

1. What are the different methods of water conveyance?

2. Practice problem related on corrected flows.

3. Practice problem on capacity of reservoir using mass-curve

Module :6

1. Difference in the design of water supply pipes and sewer pipe.

2. Design and planning of sewerage system.

Module :7

1. What is design of sewers?

2. What are the effects of flow variation on velocity in a sewer?

3. Practice Problem related on Velocity of sewer.

Module :8

1. Draw Partial flow diagrams and Nomo grams of sewerage system

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Environmental Engineering** Subject Code: **CE-701**
Year: **4th Year** Semester: **7th**

Module :9

1. What are the Physical, chemical and biological characteristics

2. Define DO, BOD and COD

3. Practice problem related with BOD & COD

Module :10

1. Draw a typical flow chart for wastewater treatment.

2. Describe Primary Treatments & Secondary Treatments.

3. Describe activated Sludge Process, Trickling Filter Process, Septic Tank

UNIVERSITY OF ENGINEERING & MANAGEMENT,JAIPUR

Lecture-wise Plan

Subject Name: Water Resource Engineering **Subject Code-CE 702**
Year: 4th Year **Semester: Seventh**

Module Number	Topics	Number of Lectures
1.	Catchment area and Hydrologic cycle, Measurement of rainfall – Rain gauges, Estimation of missing rainfall data, checking of consistency, Optimum number of Rain gauges. Calculation of average rainfall over area – different methods, Frequency analysis of rainfall intensity duration curve. Rainfall mass curve, hyetograph, Examples Evaporation, evapo-transpiration and infiltration: Processes, Factors affecting run off, estimation of run-off, rainfall run off relationship.	**8 L**
2.	Stream flow measurement: Direct and indirect methods, Examples. Stage discharge relationships Hydrographs; characteristics: Base flow separation. Unit Hydrographs. Derivation of unit hydrographs, S-curve, flood routing. Types of Irrigation systems, methods of irrigation: Water requirements of crops: Crop period or Base period, Duty & Delta of a crop, relation between Duty & Delta, Duty at various places, flow Duty & quantity Duty, factors affecting Duty, measures for improving Duty of water, crop seasons.	**8 L**
3.	Canal Irrigation: Introduction, classification of irrigation canals, efficient section, certain important definitions, Time factor, Capacity factor, full supply coefficient, Nominal duty, Channel losses, Examples. Design of unlined alluvial channels by silt Theories: Introduction, Kennedy's theory, procedure for design of channel by Kennedy's method, Lacey's theory, concept of True regime Initial regime and final regime, design procedure using Lacey's theory, examples.	**9L**
4.	Water logging and drainage: Causes, effects and prevention of waterlogging. Type of drains-open drains and closed drains (introduction only), Discharge and spacing of closed drains. Examples. Lining of Irrigation Canals: Objectives, advantages and disadvantages of canal lining, economics and requirements of canal lining, Design of lined Canals examples.	**9L**
5.	Introduction to ground water flow, Darcy law; Wells: Definition, Types-open well or Dug well, Tube well, open well-shallow open well, deep open well, cavity formation in open wells, construction of open wells, Yield of an open well – Equilibrium pumping test, Recuperating test, examples, Tube wells – Strainer type, cavity type, slotted type. Examples.	**10L**
Total Number Of Hours = 44		

Faculty In-Charge HOD, CE Dept.

Assignment:
Module 1:

1. **A)** Define irrigation. What is the necessity of irrigation?
   B) Discuss the hydrological water budget equation.

2. A) what is hydrological cycle? Explain it with suitable sketch diagram.
   B) What are the techniques of water distribution in the farms? Explain in brief.

3. A) what are the advantages of canal lining?
   B) What are the consumptive uses of water? Explain the factor affecting consumptive use of water

Module 2:

1. Write short notes –
   A) Capillary and Hygroscopic Water
   B) Channel routing
   C) Penman's method

.

2. A) Derive the relation between Duty and Delta.
   B) Define precipitation. Explain different forms of precipitation?

3. A) Explain crop period and base period?
   B) What are the precaution to be taken for controlling water-logging?

Module 3:

1. A) Explain double mass curve.
   B) Lake had a water surface elevation of 103.200 m above datum at the beginning of a certain month. In that month the lake received an average inflow of 6.0 m3/sec from surface runoff sources. In the same period the outflow from the lake had an average value of 6.5 m3/sec. Further, in that month, the lake received a rainfall of 145 mm and the evaporation from the lake surface was estimated as 6.10 cm. Write the water budget equation for the lake and calculate the water surface elevation of the lake at the end of the month. The average lake surface area can be taken as 5000 ha. Assume that there is no contribution to or from the ground water storage.

2. A) what do you understand with adequacy of rain gauge stations?
   B) Catchment has six rain gauge stations. In a year, the annual rainfalls recorded by the gauges are as follows:

Station	A	B	C	D	E	F
Rainfall (cm)	82.6	102.9	180.3	110.3	98.8	136.7

For a 10% error in the estimation of the mean rainfall, calculate the optimum number of stations in the catchment.

Module 4:

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Lecture-wise Plan

1. A)

S. No.	Isohyets (cm)	Area (square km)
1	Station-12	30
2	12.0-10.0	140
3	10.0-8.0	80
4	8.0-6.0	180
5	6.0-4.0	20

Estimate the mean precipitation due to storm.

B) The ordinates of a 3 hour unit hydrograph are given below :
Find the ordinates of a 6 hour unit hydrograph for the same.

Time in hour	0	03	06	09	12	15	18	21	24	27	30
Ordinate m^3/sec i.e. cumec	0	10	25	20	16	12	09	07	08	03	00

2. A) Differentiate ϕ index and W index.
B) B) Design a trapezoidal shaped concrete lined channel to carry a discharge of 200 cumec at a slope of 30 cm/km. The side slopes of the channel are 1.5 : 1. The value of N may be taken as 0.017. Assume limiting velocity in the channel as 2 m/s.

Module 5:

1. A) Compare Lacey's theory with Kennedy's theory
B) Calculate the value of ϕ-index from the following data of storm of 8 cm precipitation that resulted in a direct runoff of 4.4 cm :

Time in Hr.	1	2	3	4	5	6
Incremental Rainfall per	0·57	0·58	1·25	3·00	1·40	1·2

2. A) What do you mean by initial regime, final regime and permanent regime ?
B) Explain field capacity and permanent wilting point ?
C) A) Locations of rain gauge stations on a river basin A, B, C, D,E, F is forming a regular hexagon of side 5 km. Rainfall recorded in each of them are as follows :

St^n_	*A*	*B*	*C*	*D*	*E*	*F*
Rainfallincm	4·6	3·9	6·9	10·6	12·7	4·2

Calculate the mean rainfall by Thiessen Polygon method and Arithmetic mean method.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Advanced Foundation Engineering Subject Code: **CE-703A**

Year: **4th Year** Semester: **Seventh**

Module Number	Topics	Number of Lectures
1	**Soil Exploration and Site Investigation**	**4L**
	1. Planning of soil exploration programme, Field testing, Preparation of bore-log and soilinvestigation report	2L
	2. Geo-physical exploration: Seismic refraction survey electrical resistively method	2L
2	**Shallow Foundations**	**10L**
	1. Bearing Capacity from SPT and SCPT and Plate load Test data, Proportioning of footing based on settlement criteria.	4L
	2. Beams on elastic foundation: Infinite beam, Finite beam, Modulus of sub-grade reaction and effecting parameters.	4L
	3. Raft Foundation: Settlement and Bearing Capacity analysis, Analysis of flexible and rigid raft as per IS 2950.	2L
3	**Deep Foundations**	**8L**
	1. Pile: Tension piles, Laterally loaded piles: Elastic continuum approach, Ultimate load Analysis, Deflection and maximum moment as per IS 2911, Pile load test	4L
	2. Drilled Shaft: Construction procedures, Design Considerations, Load Carrying Capacity and settlement analysis	2L
	3. Caissons: Types, Sinking and control.	2L
4	**Retaining walls and sheet pile structures**	**8L**
	1. Gravity, cantilever and counter fort retaining walls: Stability checks and design	4L
	2. Sheet Pile Structures: Cantilever sheet piling, Anchored sheet piling: Free and fixed earth support methods of Analysis, Braced Excavation	4L
5	**Design of foundation for vibration control**	**4L**
	1. Elements of vibration theory, Soil-springs and damping constants, dynamic soil parameters	2L
	2. Types of Machine foundations, General consideration in designing dynamic bases.	2L
6	**Foundations on expansive soils**	**2L**

Total Number Of Hours = 36L

Faculty In-Charge HOD, CE Dept.

Module-1(Soil Exploration and Site Investigation):

1. What are the different methods of boring? Write about them in brief.
2. Discuss about seismic refraction survey.

Module-2 (Shallow Foundations):

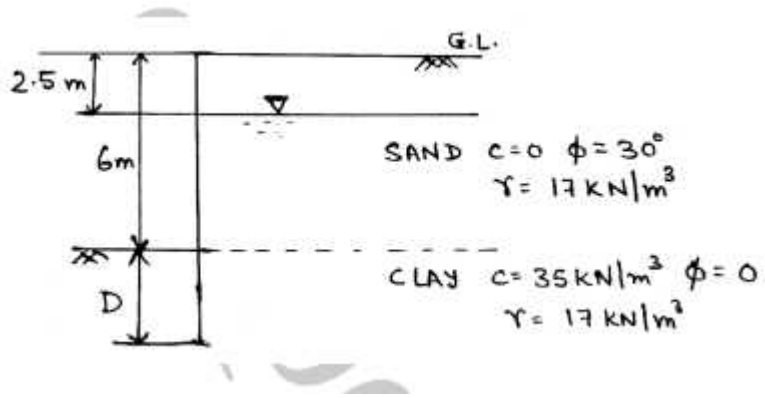
1. What is a shallow fountion? Discuss about different types of shallow foundation with their sketches.
2. What is bearing capacity? What are the limitations of plate load test?
3. Design a RCC footing for a 1 m wide concrete wall carrying a load of 800 kn/m. The allowable pressure is 200 kN/$m^{2.}$
4. What are the different types of Raft foundation?

Module-3 (Deep Foundations):

1. Write about different type of piles and their use in brief.
2. Explain 'group action of piles'.
3. A concrete pile, 40 cm diameter, is driven 25m into a soft clay (c_u=25 kN/m^2, Υ=19 kN/m^3). Determine the allowable load.
4. What are the advantages and disadvantages of pneumatic cassions?
5. Determine the outside diameter of an open caisson to be sunk through 40m of sand and water to bed rock if the allowable bearing capacity is 2000 kN/m^2. The cassion receives a load of 50 MN from the supersturcture. The mantle friction is 30 kN/m^2

Module-4 ()Retaining walls and sheet pile structures:

1. Write about different type of retaining walls with proper sketches.
2. What is a sheet pile? What are the assumptions made to analysis an anchored sheet pile structure inder free earth method of analysis? Derive the expression of depth of embedment of an anchored sheet pile structure when driven into cohesive soil. Find the embedded depth of the anchored sheet pile as shown in the fig.



UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Advanced Foundation Engineering Subject Code: **CE-703A**

Year: **4th Year** Semester: **Seventh**

Module-5 (Design of foundation for vibration control):

1. Write short notes on:
   i) Vibration ii) damping iii) Natural frequency iv) Resonance v) Degree of freedom
2. Determine the natural frequency of a machine foundation having a base area of 2mX2m and a mass of 10 Mg, assuming the soil mass participating in vibration is a) negligible b) 20% of the mass
3. Discuss single degree freedom system in the analysis of machine foundation.

Module-6 (Foundations on expansive soils):

1. What is an expansive soil? Where is it founfd in India? What are its general characteristics?
2. Define following parameters: a) Free swell b) Unrestrained free swell c) Differencial free swell
3. A drilled pier of length 5m in an expansive soil having the depth of effective zone as 3m.If the shaft is 1m and the bulb diameter is 1.25m. Calculate the F.S for dead load.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Soil Stabilization & Ground Improvement Techniques Subject Code: **CE-703B**

Year: **4th Year** Semester: **Seventh**

Module Number	Topics	Number of Lectures
1	**Soil Stabilization**	**8L**
	1. Introduction, Stabilization of soil with granular skeleton and soil without granular skeleton,	4L
	2. common nomenclature of stabilized soil systems and stabilization methods	2L
	3. specific methods of soil stabilization: Stabilization with cement, lime fly-ash	2L
2	**Insitu densification**	**12L**
	1. Introduction, Compaction: methods and controls	2L
	2. *Densification of granularsoil***:** Vibration at ground surface, Impact at ground surface, Vibration at depth (Vibroflotation), Impact at depth.	5L
	3. *Densification of Cohesive Soils*: Preloading and dewatering, Design of Sand drains and Stone columns, Electrical and thermal methods	5L
3	**Geo-textiles**	**6L**
	1. Over view	1L
	2. Geotextiles as separators, reinforcement.	2L
	3. Geotextiles in filtration and drainage, geotextiles in erosion control.	3L
4	**Grouting**	**6L**
	1. Over view	1L
	2. Suspension and Solution grout	1L
	3. Grouting equipment and methods	2L
	4. Grout design and layout, Grout monitoring schemes.	2L
5	**Soil stability**	**4L**
	1. Reinforced earth fundamentals,	1L
	2. Soil nailing, Soil and Rock Anchors,	2L
	3. Underpinning	1L
Total Number Of Hours = 36L		

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Module-1(Soil Stabilization):

1. Write short notes on:
   i) Cement and lime stabilization. ii) Thermal stabilization
2. Explain deferent methods of stabilization.

Module-2 (Insitu densification):

1. Write about the stabilization methods for cohesionless soils.
2. What are the methods for stabilizing cohesive soils.
3. Discuss various compaction equipment for surface compaction in field.

Module-3 (Geo-textiles):

1. How can you use geotextiles in
   i. Drainage and filtration
   ii. Reinforcement
   iii. separators

2. Give the advantages and disadvantages of geo-grids for soil reinforcement in comparison to steel strips.

Module-4 (Grouting):

1. What is grouting? What are the types of grout?
2. Describe various methods of grouting

Module-5 (Soil stability):

1. What is reinforced earth? Check the reinforced earth wall for stability against i) sliding ii) overturning and iii) bearing failure. Although BC is a rough surface, assume it to be smooth
2. Write about soil nailing.
3. What are the types of anchors? Describe various uses of anchors with diagrams.

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Course Description

Title of Course: **Advanced Highway and Transportation Engineering**
Course Code: CE703C
L-T Scheme: 3-0 **Course Credits: 3**

Introduction:

This course provides an introduction to advance highway engineering and is designed for civil engineering students. The Topics to be covered (tentatively) include:

- Introduction to Highway Engineering
- Advance Highway Alignment
- Advance Highway Geometric Design
- Advance Traffic Engineering
- Road Materials and Testing

Objectives:
This course covers Advance highway studies in city and regional perspectives such as its importance, technical studies, economic viability details, road use analysis and financial studies. The course further covers advance road design and advance construction methods, road geometry and layout designs such as the cross sectional elements, road alignments principles and aesthetics among others. It further covers highway construction materials and maintenance

Learning Outcomes:
Knowledge:
On successful completion of the course students will be able to:

1. Demonstrate highway terminology and Traffic Studies .
2. Demonstrate the design requirements for roads and highways and design of flexible and rigid pavements.
3. Demonstrate the construction and inspection requirements of roads by undergoing various test.
4. Gain in depth knowledge on various types of pavement, pavement materials.
5. Demonstrate safety, traffic analyses and vehicle abilities in the design of roads.

Course Contents:

Unit 1 Traffic Studies: Road inventories, Traffic Volume Studies, Spot Speed Studies, Travel Time and delay Studies, Origin-Destination studies, Methodology and Analysis of O-D data, Traffic capacity, Parking studies and characteristics, Accident studies and characteristics, causes and preventive measures.

Unit 2: **Statistical Methods for Traffic Engineering**: Elementary concepts and Probability, Mean, Standard Deviation and variance, Poisson and Binomial Distribution, Normal distribution, sampling Theory and Significance testing, Linear Regression and correlation.

Unit 3: Traffic Characteristics: Macroscopic and Microscopic Characteristics related to Volume, Speed and Density, their relationships, Road User Characteristics – Human and vehicular Characteristics.
Traffic Engineering Design: Principles of Road Junction design, Design of Roundabouts, Bus Stops and Parking Lots, Design of Signals.

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

Course Description

Unit 4: Traffic Management: Traffic Laws, Regulations and Ordinances for Drivers, Pedestrians and Mixed Traffic. Traffic control Measures – One Way streets, Kerb Parking Control, Intersection Control, Speed Control, Access Control. Expressways. Traffic Control Devices – Traffic Markings, Signs, Signals, Traffic Islands, their Classification, types and Sketches, Street Lighting.

Unit 5: Traffic and Environment: Detrimental Effects of Traffic on the environment – air pollution, noise pollution, visual intrusion, aesthetics etc.
Road Safety: The identification of problem, causation and Prevention, Road layout and Improvements, Safety equipment.

Text Books

1. Khanna & Justo N, “High Way Engineering”, Nemchand & Brothers, Roorkee
2. P. Chakraborty & A. Das, “Principles of Transportation Engineering”, Prentice Hall India.
3. I.S Specifications on Concrete, Aggregate & Bitumen, Bureau of Indian Standard

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Advanced Structural Engineering **Subject Code-CE704A**

Year: 4th Year **Semester: Seventh**

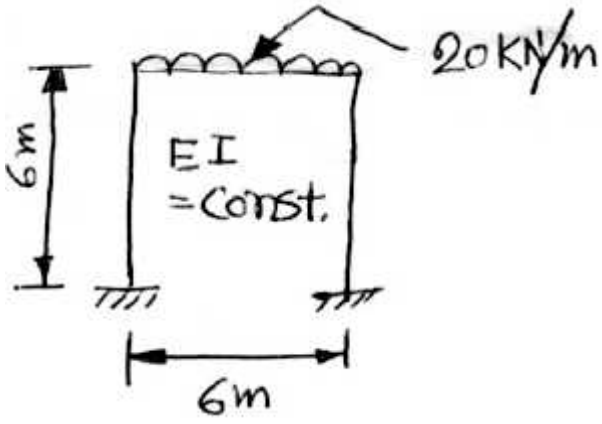
Module Number	Topics	Number of Lectures
1	**Introduction: Matrix methods of analysis:**	**9L**
	1. Matrix formulation of redundant beam analysis.	2
	2. Stiffness and flexibility approaches for beams, simple portal frame, trusses.	7
2	**Dynamic analysis of structural frames:**	**6L**
	1. Wind analysis of structures by using I.S Code provisions	3
	2. Seismic analysis as per IS 1893	3
3	**Theory of plates and shells:**	**10L**
	1. Thin plate analysis.	2
	2. Differential equation of bending under point and uniformly distributed load, various support systems.	2
	3. Rectangular and circular plates.	2
	4. Membrane analysis of thin shell, meridional & hoop stress, shell of revolution, cylindrical shell, applications.	4
4	**Introduction to finite element:**	**9L**
	1. Potential Energy, shape function,	2
	2. Linear, triangular and rectangular element,	3
	3. Fundamentals for one-dimensional, two dimensionalstructure,	2
	4. Isoparametric formulation, simple two dimensional problems related to civil engg.	2
Total Number Of Hours = 34		

Faculty In-Charge HOD, CE Dept.

Assignment:

Module-1(Matrix methods of analysis):

1. Analysis the portal frame by stiffness method.



2. Write a short note on statical indeterminacy and kinematic indeterminacy.

Module-2 (Dynamic analysis of structural frames):

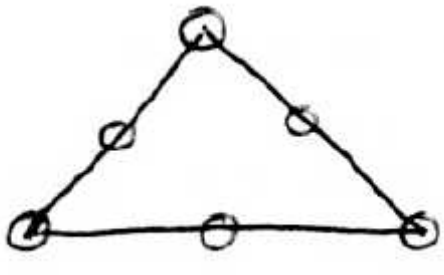
1. Discuss equivalent lateral load design method and response spectrum method as per IS 1893.

Module-3(Theory of plates and shells):

1. Write a short note on thin plate analysis.
2. Write down the different parts of cylindrical shell.

Module-4(Introduction to finite element):

1. Write a short note on finite element technique.
2. The figure below is 2D element. Find the shape function using Lagrangian shape function.



3. Write a short note on mesh reinforcement in Finite element method.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: **Hydraulic Structures** Subject Code: **CE704B**

Year: **4th Year** Semester: **Seventh**

Module Number	Topics	Number of Lectures
1	**Chapter 1: Diversion Head works**	**6L**
	1. Necessity, Difference between weir and Barrage, Type of Weirs, Selection of site, layout	2L
	2. Elements of weir, Effects of construction of a weir on the river regime	**2L**
	3. Causes of failure of weirs on permeable foundation and their remedies	2L
2	**Chapter 2: Theories of seepage and Design of weirs and Barrages**	**6L**
	1. Failure of Hydraulic Structures Founded on Pervious foundations: i)By piping ii) By Direct uplift, Bligh's creep theory of seepage flow	1L
	2. Khosla's theory & concept of flow nets, concept of exit gradient and critical exit gradient	2L
	3. Khosla's method of independent variable for determination of pressures and exit gradient for seepage below a weir or a barrage, necessary corrections, examples.	3L
3	**Chapter 3: Hydraulic structures for canals**	**5L**
	1. Canal falls–necessity, locations, types and description of Ogee-fall	2L
	2. Trapezoidal-notch fall, Syphon well drop, Examples.	3L
4	**Chapter 4: Cross-Drainage Works ,**	**4L**
	1. Necessity, types	2L
	2. Selection of a suitable type (Introduction only).	2L
5	**Chapter 5: Dam**	**6L**
	1. Definition, classification of Dams, factors governing selection of type of dam, selection of suitable site for a dam	2L
	2. Earthen Dams: Introduction, Types of Earthen Dams, Methods of Construction, Causes of failure,	2L
	3. Design Criteria, Determination of line of seepage or phreatic line in Earthen Dam, seepage control in Earthen Dam, Examples.	2L

6	**Chapter 6: Gravity Dam**	**6L**
	1. Definition, Typical cross-section, Forces acting on Gravity Dam, Combination of forces for design,	1L
	2. Mode of failure and criteria for structural stability of Gravity Dams, Principal and shear stresses. Elementary profile of a Gravity Dam	2L
	3. Concept of High and low Gravity Dam, Examples	1L
	4. Spillways: Types, Location, Essential requirements, spillway capacity. Components of spillway, Energy Dissipators, Stilling basins (Indian standard).	2L
Total Number Of Hours = 33L		

Assignment:

Module-1:

1. Sketch a neat diagram of a layout of a diversion head work and show the different components on it.
2. The following data are used in the design of glacis-type weir: maximum flood discharge = 1800 m^3/s; HFL before construction = 300.00 m AOD; river bed level = 293.00 m AOD; normal upstream pond level = 299.00 m AOD; allowable afflux = 1m; permissible exit gradient = 1 in 6; silt factor f =1; crest level of canal regulator = 297.50 m AOD; FSL downstream of canal regulator = 296.00 m AOD; canal bed level downstream of regulator = 293.50 m AOD. Design the various elements of the weir foundations using Bligh's theory Given k_p = 0.01, k_a= 0.1 (assume other necessary values).

Module-2:

1. What are the limitations of Bligh's theory for sub-surface flow below a weir?

2. How Bligh's theory differ from Khosla's theory?

Module-3:

1. How irrigation canals are classified?

2. Describe briefly various considerations made in the alignment of an irrigation canal.

3. Write short notes on (a) Canal fall (b) Canal regulators

Module-4:

1. What are cross-drainage works? What is their necessity?

2. How is the choice of cross-drainage works is made? Draw a neat sketch of an aqueduct.

Module 5:

1. Explain the influence of following factors on the choice of the types of dam:

a) Geology and foundation condition

b) Spillway size and location

2. Explain the thin cylinder theory of design of an arch dam.

Module 6:

1. Determine the forces exerted by the waves on the upstream face of a concrete gravity dam.

2. Explain step by step method of design of gravity dam.

3. Explain the foundation treatment for a gravity dam.

4. A spillway is to discharge water 30 $m^3/s/m$ lenth. The maximum water level above the river bed is 35 m. The upstream face is vertical and the downstream face has a slope of 0.75 H to 1 V. Design the profile of a spillway crest.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lecture-wise Plan

Subject Name: Engineering Materials Subject Code-CE705A

Year: 4th Semester: Seventh

Module Number	Topics	Number of Lectures
1	**Introduction to Engineering Materials**	**6L**
	Introduction to Material Science and Discussion about Course	1L
	Crystal Structures and Lattices.	1L
	Crystal Imperfections, Slip and Dislocations	1L
	Elasticity and Plasticity, Plastic Deformations	1L
	Hot and Cold Working of Metals, Recovery, Recrystallization and Grain Growth	2L
2	**Phase Diagram**	**6L**
	What is a Phase Diagram and its importance	1L
	Solidification and structures of metal and alloys	1 L
	Iron Carbon Phase Diagram	1 L
	Properties of metals – Mechanical, Physical and Electrical	1 L
	Binary and Ternary phase Diagrams	2 L
3	**Study of Microstructures**	**4L**
	Powder Metallurgy and its applications	2L
	Fatigue, Creep, Slip and Dislocations	2L
4	**Heat Treatment Procedures**	**5L**
	Annealing and types of annealing	2L
	Tempering and Normalising	1L
	Hardening and types of hardening process	1L
	Various types of furnaces	1 L
5	**Special types of steel**	**5L**
	Tool Steel and their classification	2L
	Cast Iron and its classification	2L
	Stress strain relationship and it properties	1L
6	**Non Ferrous Metals and its types**	**6L**
	Copper and its types, Properties of copper	1L
	Aluminium and its uses, types and its properties	1L
	Alloys and effect of alloying in steel	2L
	Semiconductors and Composites	2L
Total Number Of Hours = 32		

Assignment No. 1

1. What is LASER? Explain the principle of operation of He-Ne laser.
2. What are optical fibers? Discuss its principle of operation.
3. Discuss about the performance of metals & ceramics at high temp.
4. Differentiate between addition & condensation polymerization.
5. What are ferroelectric materials? Discuss about different types of ferro-electric materials.
6. What are the functions of matrix phase in a fiber- reinforced composite?
7. Derive an expression for electric polarization of di-electric in an electric field .
8. Explain the Ferro-electric phenomena w.r.t $BaTiO_3$.
9. Explain the methods of preventions of following types of corrosion:
a. dezincification
b. season cracking
c. caustic embrittlement of boilers
d. intergranular corrosion of steel.
10. Discuss about silicate structures.

Assignment No. 2

11. Differentiate between type-1 & type-2 superconductors with examples.
12. Explain the principle of operation of Ruby laser.
13. Discuss the various applications of optical fiber.
14. Assume that electron is a small sphere of radius R, its charge & mass being distributed uniformly through out its volume. Derive an expression for its spin magnetic moment. [This model of the electron is too mechanistic to be in the spirit of quantum physics view of this particle].
15. Discuss the advantages & dis-advantages of classical free electron theory.
16. Explain how a four level laser system works?
17. Derive an expression for the electronic polarizability in terms of atomic radius.
18. Draw the polymer structure for polymethyl methacrylate & polyhexamethylene adipamide. Indicate whether they are thermoplastic or thermosetting polymers. Mention one application of each polymer.
19. Compare & describe the properties of GFRP & CFRP composites.
20. What is post tensioning in re-inforced concrete? How is it carried out? State at least two applications of this material.

Assignment No. 3

21. State the mechanical properties of ceramics.
22. What is corrosion? How is it prevented for metallic materials?
23. How optical fibers are in use to improve the living conditions in the world?
24. Explain how failure models help the manufacturer to manufacture a product?
25. Derive an expression for the concentration of holes in the valence band of an intrinsic semiconductor.
26. Explain the mechanism of differential aeration of metals.Give two examples where differential aeration effects are seen.
27. What are the functions of the dispersed phase & matrix phase in composites?
28. What are the postulates of Drude –Lorentz theory of metals?
29. Give the mechanism of addition and condensation polymerization. What is the minimum functionality required for a monomer to form a cross- linked polymer?
30. Describe the steps to be adopted in the production of bricks for
(a) Civil construction work

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Lecture-wise Plan

Subject Name: Engineering Materials Subject Code-CE705A
Year: 4th Semester: Seventh
(b)Refractory linings.

Assignment No. 4

31. Give the comparison between ferromagnetic, ferromagnetic and ant ferromagnetic substance.
32. Enumerate the potential use of composite materials.
33. Menntion few examples to highlight the applications of Ceramics in medical science, interior decoration and in electronic gadgets.
34. Derive an expression for the numerical aperture of a step index optical fibre in terms of refractive indices of core and cladding.
35. Enumerate the different methods to control or to prevent the corrosion of metals.
36. Discuss various characteristics of ceramics of ceramic white ware products and their industrial applications.
37.Derive an expression for the thermal conductivity of a material in terms of mean free path average speed of electrons.
38. What are the advantages and dis-advantages of plastics?
39. What is R.C.C? Give its composition and strength. How can you make it water proof?
40. Compare and describe the properties of GFRP and CFRP composites.

Assignment No. 5

41. Give a comparison between hard and soft ferromagnetic substance.
42. Differentiate between addition and condensation polymerization. Why does natural rubber need vulcanization? What is injection moulding of plastics?
43. Calculate the maximum percentage of sulpher that can be present vulcanized rubber.
44. Explain pitting corrosion. Discuss important methods for corrosion control.
45. Mention mechanical properties of ceramics. What are its important applications?
46. Find the number-average molecular weight of a sample of PTEE for which the number average degree of polymerization is 296.
47. What is Hall Effect? How you will determine the mobility of electrons in germanium knowing only the resistivity & Hall-coefficient of it.
48. The fermi energy in copper at 0k on the assumption that each copper atom contributes one electron to the electron gas is 7.04 ev .Calculate the Fermi energy & average energy of an electron in the metal at 300k.
49. Explain how failure analysis of material selection helps the manufacturer to manufacture a better product.
50. What is acceptance angle in optical fiber? Derive an expression for the numerical aperture of a step-index optical fiber in terms of its refractive indices of core & cladding.

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Lecture-wise Plan

Subject Name: **ELECTRICAL & ELECTRONIC MEASUREMENT** Subject Code: **CE705B**

Year: **2nd Year** Semester: **Seventh**

Module Number	Topics	Number of Lectures
1	**Introduction :**	**11L**
	1. Method of measurement, Measurement system, Classification of instruments	1L
	2. Definition of accuracy, Precision, Resolution, Speed of response	1L
	3. Error in measurement, Classification of errors	1L
	4. loading effect due to shunt and series connected instruments	2L
	5. General features, Construction, Principle of operation and torque equation of Moving coil, Moving iron, Electrodynamometer, Induction instruments	3L
	6. Principle of operation of the Electrostatic, Thermoelectric, Rectifier type instruments	2L
	7. Extension of instrument ranges and multipliers	1L
2	**Instrument transformer**	**9L**
	1. Disadvantage of shunt and multipliers, Advantage of Instrument transformers	1L
	2. Principle of operation of Current & Potential transformer, errors	3L
	Measurement of power	
	1. Principle of operation of Electro dynamic & Induction type wattmeter. Wattmeter errors.	2L
	Measurement of resistance	
	1. Measurement of medium, low and high resistances, Megger.	3L
3	**Measurement of Energy**	**3L**
	1. Construction, theory and application of AC energy meter	2L
	2. testing of energy meters	1L
	Potentiometer	**3L**
	1. Principle of operation and application of Crompton's DC potentiometer	1L
	2. Polar and Co-ordinate type AC potentiometer. Application	2L

	ACBridges	**4L**
	1. Measurement of Inductance, Capacitance and frequency by AC bridges.	4L
4	**Cathode ray oscilloscope(CRO)**	**3L**
	1. Measurement of voltage, current, frequency & phase by oscilloscope	1L
	2. Sampling and storage oscilloscope	1L
	3. Double beam CRO.	1L
	Electronic Instruments	**4L**
	1. Advantages of digital meter over analog meters, Digital voltmeter, Resolution and sensitivity of digital meters	2L
	2. Digital multimeter, Digital frequency meter, Signal generator	2L
	Sensors &Transducers	**3L**
	1. Introduction to sensors &Transducers, Strain gauge	1L
	2. LVDT, Temperature transducers	2L
	3. Flow measurement using magnetic flow measurement.	1L
Total Number Of Hours = 40L		

Assignment:

Module-1(Introduction):

1. The following data refer to measurement in a single phase AC load

Instrument	Reading	Full scale	Maximum uncertainty as % of full scale
Voltmeter	200 V	2A	1%
Ammeter	2A	2A	0.5%
Wattmeter	320W	480W	1%

   Find the power factor of the load and maximum percentage of uncertainty in the value obtained?
2. Define accuracy sensitivity, dead zone and reproducibility?
3. A voltage has a true value of 1.50V. An analog indicating instrument with a scale range of 0-2.50V shows a voltage of 1.46V. What are the values of absolute error and correction? Express the error as a fraction of true value and the full scale deflection?
4. Explain loading effect due to shunt connected instrument?
5. A multimeter having a sensitivity of 2000Ω/V is used to measure the voltage across a circuit having an output resistance of 10kΩ. The open circuit voltage of the circuit is 6V. Find the reading of the multimeter when it is set to it's 10V scale. Find percentage error due to loading effect?
6. Explain Dynamic characteristic of a measurement system?

7. Describe eddy current damping and air friction damping technique used in indicating type instrument?
8. Differentiate absolute error and relative error?
9. A 0-150 V voltmeter has a guaranteed accuracy of 1% of full scale reading. The voltage measured by this instrument is 75 V. Calculate the limiting error in percentage?
10. Describe the spring control technique and gravity control technique used in indicating type instrument?

Module-2 (Power and resistance measurement , Instrument transformer):

1. Explain Loss of charge method for high resistance measurement?
2. Describe direct deflection method of measuring high resistance?
3. Draw the equivalent circuit and phasor diagram of a current transformer?
4. What do you mean by Ratio error in practical current transformer?
5. The magnetising current of a ring core current transformer, of ratio 1000/5 A, when operating at full primary current and with a secondary burden of non inductive resistance of 1 Ω is 1 A at a power factor of 0.4. Neglecting the effect of magnetic leakage, calculate-
   i) The phase displacement between primary and secondary currents?
   ii) The ratio error at full load assuming that there has been no turn compensation?
6. Mention the difference between Current Transformer and Potential Transformer?
7. Derive the expression for bridge sensitivity while measuring unknown resistance using Wheatstone bridge method?
8. State and explain Blondel's theorem?
9. How three phase power can be measured using 3 watt meters?
10. Describe how three phase power can be measured using only two watt meters?

Module-3(AC Bridges, Potentiometer, Measurement of Energy):

1. How capacitance can be measured using De Sauty's bridge
2. Describe the operation of a DC potentiometer and also explain how standardisation of this instrument is done to get direct reading for measurement of unknown voltage?
3. Describe the operation of phase shifting transformer?
4. Explain how AC potentiometer works?
5. A basic slide wire potentiometer has a working voltage of 3V with negligible internal resistance. The resistance of slide wire is 400Ω and it's length is 200 cm. A 200 cm scale is placed along the slide wire. The slide wire has 1mm scale divisions and it is possible to read up to 1/5 of a division. The instrument is standardised with 1.018V standard cell with sliding contact at the 101.8 cm mark on scale. Calculate –
   i) Working current?
   ii) The resistance of series rheostat?
   iii) The measurement range?
   iv) The resolution of instrument?
6. How unknown frequency can be measured using Wien's bridge ?
7. In a Wheatstone bridge the value of resistances of various arms are P=1000 Ω, Q=100 Ω, R=2005 Ω and S=200 Ω. The bridge is balanced when PS=RQ. The battery has an emf of 5V and negligible internal resistance. The galvanometer has a current sensitivity of 10 mm/μA and an internal resistance of 100 Ω. Calculate the deflection of galvanometer and the sensitivity of the bridge in terms of deflection per unit change in resistance?
8. Derive the expression of unknown inductance for measurement of inductance using Anderson's bridge? Also draw the phasor diagram of the bridge at balanced condition?

9. Explain the significance of standardization of potentiometer? How potentiometer gives more accurate result than voltmeter while measuring unknown voltage?

10. Explain how self-inductance can be measured using Maxwell's Inductance Bridge?

Module-4(Electronic instruments, CRO, Sensors and Transducers):

1. Describe how thermocouple can be used for temperature measurement?
2. Write down the difference between sensors and transducers? Define Strain Gauge?
3. Prove that $G_f = 1 + 2\gamma$

   Where G_f is the gauge factor of the strain gauge and γ is the Poisson's ratio.
4. Explain the operating principle of LVDT?
5. Describe the block diagram of Cathode Ray Oscilloscope and explain each block?
6. A resistance strain gauge with a gauge factor of 2 is cemented to a steel member which is subjected to a strain of $1x\ 10^{-6}$. If the original resistance value of the gauge is 130 ohm calculate the change in resistance?
7. How temperature is measured using thermocouple?
8. Write short note on RTD?
9. What are the main advantages of digital meter over analog meters
10. Explain the operation of a signal generator?

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lab Manual

Title of Course: Environmental Engineering Lab
Course Code: CE 791
L-T-P scheme: 0-0-3 **Course Credit: 2**

Objectives:
1. The students will be able to determine the Bio Chemical Oxygen demand for a given sample of waste water.
2. They will be able to determine the Chemical Oxygen Demand for a given sample of waste water.
3. The students will be able to determine the total solids, suspended solids and dissolved solids in a given sample of water.

Learning Outcomes: The students will be able to develop a clear understanding of the different physical, chemical and physiological tests conducted on water. They will be able to determine the Ph, concentration of chlorides, carbonates, bi-carbonates, hydroxide alkalinity, fluorides, iron and optimum alum dose for a given sample of water. The students will also develop the knowledge of determining the chlorine percentage in a given sample of bleaching powder.

Course Contents:
Practicals that must be done in this course are listed below:

1. Determination of turbidity for a given sample of water.
2. Determination of colour for a given sample of water
3. Determination of solids in a given sample of water: Total Solids, Suspended Solids and Dissolved Solids.
4. Determination of pH for a given sample of water.
5. Determination of concentration of Chlorides in a given sample of water.
6. Determination of carbonate, bi-carbonate and hydroxide alkalinity for a given sample of water.
7. Determination of hardness for a given sample of water.
8. Determination of concentration of Fluorides in a given sample of water.
9. Determination of concentration of Iron in a given sample of water.
10. Determination of the Optimum Alum Dose for a given sample of water through Jar Test.
11. Determination of the Residual Chlorine in a given sample of water.
12. Determination of the Chlorine Demand for a given sample of water.
13. Determination of the Available Chlorine Percentage in a given sample of bleaching powder
14. Determination of amount of Dissolved Oxygen (DO) in a given sample of water.
15. Determination of the Biochemical Oxygen Demand (BOD) for a given sample of wastewater.
16. Determination of the Chemical Oxygen Demand (COD) for a given sample of wastewater.
17. Determination of bacteriological quality of water: presumptive test, confirmative test.

Text Book:
1. Environmental Engineering And Solid Waste Management By S.K.Garg.

Ex No: 1 Study of sampling and preservation methods. Significance of characterisation of water and waste water.

Aim

To study the sampling and preservation methods in water and waste water characterization and to learn the significance of characterisation of water and waste water

Sampling Programme and Procedures

The collection of a representative sample is the most important function of an environmentalist. The interpretation of results and recommendation for prevention and corrective treatment are all based on the analysis report. Scrupulous care in the collection of samples is therefore necessary to ensure that the sample is representative of the body of water under examination and to avoid spoilage and accidental contamination of the sample during collection and transport.

Methods of sampling

Three types of samples are often collected depending on situations

a. Grab Samples

Grab samples are samples collected at a designated place at a particular time. They represent the composition at the time and space. When a source is known to vary in time, as in the case of waste effluents, grab samples collected at various time intervals and analysed separately can be of greater value.

b. Composite samples

Composite samples are a mixture of grab samples collected at one sampling point at different times. Individual samples are collected in wide mouth bottles every hour and mixed in volume proportional to the flow. The composite values are useful for observing average values.

c. Integrated samples

Integrated samples are a mixture of grab samples collected from different points simultaneously and mixed in equal volumes. Individual samples are collected from both banks of a river and at varying depths to represent available situations.

Sampling and preservation Requirements:

1. Physical and Chemical Requirements:

For general physical and chenica1 examination, the sample should be collected in a chemically clean bottle made of good quality glass fitted with a ground glass stopper or a chemically inert polyethylene container. The volume of sample to be collected would depend

on the selection of tests; however, for general examination 3.0 litre sample would be sufficient,

The following precautions must be taken while collecting the sample

i) The sampling location is representative of the water body

ii) The place is devoid of floating material

Where ever possible the sample should be collected 15cm, below the surface or as the situation warrants

No physical activity is permitted upstream of sampling point Shorter the time between collection and examination, the reliable will be the analytical results. For certain constituents and physical values, immediate analysis in the field is required, because, the composition of water may change before it arrives at the laboratory.

The maximum limits of storage are:

Unpolluted water: 72 hours Slightly polluted. : 48 hours Grossly polluted: 1 2hours

Some determinations are more likely to be affected by storage than others. Temperature may change, pH may change significantly, and dissolved gases may be evolved and lost (O2, CO2. and H2S)

Frequency of sampling:

Frequency depends on objectives. Yet, collection of samples of both raw and treated waters should be carried out as frequently as possible and at least once in every three months. Some waters undergo more pronounced seasonal variation and therefore require more frequent testing. Samples from treatment units should be collected and analyses frequently, at least one from each unit daily.

2. Bacteriological requirements:

The samples for bacteriological examination are collected in sterilized. neutral glass, glass-stopper 80z, and 300 ml bottles. The stopper and the neck should be protected by paper or parchment cover. If the sample is likely to contain traces of residual chlorine, an amount equal to 3.0 mg of sodium thiosul1ite (Na2s203, 51120) to neutralize chlorine is added to the bottle before sterilization. The sterilization is done at 15 psi (121°C) for 20-30 minutes in an autoclave.

The sterilized sample bottle should be kept unopened until the time of collection. The stopper should be removed with care to eliminate chances of spoiling and contamination and should never the rinsed. After filling, the stopper should be replaced immediately. The place of collection should be predetermined and procedure of collection conditioned depending on the source.

The standard procedure in sampling from a water faucet or tap is as follows:

a) Flame the tap briefly to kill clinging bacteria. This can be done with a piece of burning paper.

b) Turn on the water and allow it to run for 1 mm.

c) Remove the stopper from the bottle, being careful not to touch the inner portions o the stopper or bottle neck.

d) Fill bottle carefully, allowing no water to enter that has come in contact with hands. It is sometimes necessary to collect a sample from a reservoir or basin. If the water can be reached, remove the stopper, plunge the bottle below the surface and move the bottle while it is filling, so that no water will enter that has been in contact with hand. If the water is out of reach, as in a dug well, the bottle can be lowered with a cord.

The sample after collection should be examined immediately, preferably within one hour. If the conditions do not permit immediate examination, the sample should be stored at low temperatures. This period should in case be more than 24 hours. If storage or transportation is necessary, they should be got at a temperature between 0°C and 10°C.

Frequency of sampling:

The frequency of sampling should be fixed depending on the magnitude of the problem involved. The number of samples to be examined from drinking water supply distribution system is normally decided on the basis of population served as given in the tabulation.

3. Biological Requirements:

In general the samples for biological examination are collected in wide mouth, clean glass bottles of 2.0 litre capacity. They are never filled completely. This method is employed when total microscopic count is the aim. In some specific cases the concentrate of a sample may be collected through plankton nets made of bolting silk cloth, or the. sample filtered through Sedge wick Rafter funnels.

In general the sample must be examined microscopically within one hour of collections. If the facilities do not permit an immediate examination, it should be preserved after collection by addition of 2 ml neutralized (pH 7.0) formaline to each 100 ml of the sample.

There is no practice about the frequency of sampling but the examination should be made regularly, or else as the situation demands. Benthos study is complex, Collection through cages placed at proper preselected sites for a defined period of time is recommended.

Significance of Characterisation of various parameters:

Natural waters are never completely pure. During their precipitation and passage over or through ground they require a wide variety of dissolved and suspended impurities. The concentrations of these impurities are seldom large in ordinary chemical sense but they modify the chemical behaviour of water or its usefulness.

The waste waters generally have values far higher than in waters.

Some of these impurities are toxic, some may affect health, and some affect the portability while others indicate pollution.

Hardness

The study of hardness is important from the point of view of industrial utilization of water especially in boilers, where scales are formed. Hardness in municipal supplies increases the consumption of soap, fuel, tea leaves etc. in the household and renders it unsuitable for use in air-conditioning.

Turbidity

It is a measure of degree of opaqueness of water and interference presented by suspended matter to the passage of light. The turbidity is due to clay, silt, finely divided organic matter and microscopic organisms. Turbidity tests are important from aesthetic consideration and from the point of economics of treatment. The most important health significance of turbidity is that may, harbour pathogenic organisms.

pH

Determinations of pH, alkalinity and its forms, along with acidity are of interest in coagulation, softening and corrosion control.

Residue or solid matter

The test for residue is of very great importance in sewage treatment processes to indicate the physical state of the principal constituents. The ratio of the weight of suspended solids to turbidity often referred as coefficient of fineness. The solids present in dissolved form are related to the electrical conductivity. The fixed solids indicate the mineral level while volatile solids are related to organic matter.

Chloride

Concentration of chlorides in municipal sewage is often significantly (15-50 mg/L) higher than those in its water supply. For this reason, a change in its concentration may be indicative of sewage pollution, in waters of low chloride concentration.

Chlorides

occur in an all natural waters in widely varying amounts. Mountain streams are normally low in chloride values. Chloride gain access to water either because of excellent solvent properties or through human excreta or industrial pollutants. Chlorides were for several years used as an indicator of pollution by municipal wastes in rivers, streams, wells and lakes.

Dissolved Oxygen

In raw water and domestic wastes, dissolved oxygen is a factor which determines whether the biological processes undergoing a change are aerobic or anaerobic. It is very desirable that aerobic conditions are maintained. It is a Single test which will immediately indicate the sanitary status of a stream. Low values of dissolved oxygen adversely affect the portability of water and may cause fish kill.

Organic matter

The tests of organic matter indicate type and extent of pollution, which has its origin in plant or animal matter. Tests are mostly restricted to the study of nitrogen in various forms and oxygen requirements in biodegradation of puterscible carbonaceous organic matter (BOD). A measure of the demand is also indicated in terms of demand through strong chemical oxidants (COD)

BOD.

The BOD is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. Polluted water does not contain sufficient oxygen in solution to maintain aerobic condition during decomposition. The quantity of oxygen required for complete stabilization is taken as a measure of its organic content.

CODP

The COD test is based on the concept that a large majority of organic compounds can be completely oxidized by the action of strong oxidizing agents in acidic medium. The quantity of oxygen required is proportional to organic matter, regardless of the biological assimilability of the substance.

Nitrogen

Nitrogen is estimated as organic nitrogen, ammonical nitrogen, nitrite nitrogen and nitrate nitrogen throw light on the pollutional history of the carrying water.

Bacteriological tests

The routine bacteriological tests are aimed at enumerating the members of coliform group, which are considered indicators of pollution. The natural habitat of these bacteria is the intestinal tract of man and other warm blooded animals. They are present wherever the pathogens are present and by their absence exclude the probability of the presence of pathogens. They share the fate of the most significant pathogenic enteric bacteria outside the human and animal body both in the rate of death and in the rate of removal when water is purified.

Another test of bacteria is aimed at detecting chemo-synthetic heterotrophic heterogeneous group developing under conditions of cultivation and is referred as

Total Plate Count. This test is not differential and indicates a total picture of bacteria associated with organic matter.

Biological Examination

The biological examination (microscopic) provides useful information for the control of water quality and treatment. It serves for one or several of the following purposes:

I. To explain the cause of color or an odor in water.
II. To aid in the interpretation of various chemical analysis reports.
III. Permitting identification of specific water when it is mixed with another.
IV. To explain clogging of pipes/screens/filters.
V. Rapidly detect organic pollution and contamination with toxic substances.
VI. To indicate the progress of self purification streams.

Ex No: 2 Determination of pH

Aim:

To determine the pH value of the given sample by electrometric method.

Apparatus Required:

pH meter with combined electrode, beakers

Chemicals Required:

Buffer tablet of pH values 4 and 9.2

Reagents preparation:

Buffer solution of pH value 4

Buffer tablet of pH value 4 is dissolved in 100 ml of distilled water. This solution should preferably be stored in a plastic bottle in cool place.

Buffer solution of pH value 9.2

Buffer tablet of pH value 9.2 is dissolved in 100 ml of distilled water. This solution should preferably be stored in a plastic bottle in cool place.

Procedure:

Electrometric method:

1. Wash the combined electrode of pH meter with distilled water and clean the same with distilled water.

2. Dip the combined electrode in the buffer solution of pH value 4.

3. Adjust the temperature by the adjustment knob to an ambient (room) temperature.

4. If the instrument shows the reading as 4 then it is in order if not, adjust the reading to 4.0 by calibration adjustment knob.

5. Wash the electrode of pH meter with distilled water and clean the same with distilled water and dip it to the buffer solution of pH value 9.2.

6. Note the reading if the instrument shows the reading as 9.2 then it is in order otherwise use the calibration adjustment knob and bring the reading to 9.2.

7. Repeat the above procedure until the meter shows reading as 4 when electrode is dip in buffer solution of pH 4 and shows reading as 9.2 when electrode is dip in buffer solution of pH value 9.2.

8. Now the instrument is calibrated.

9. After cleaning the electrode dip in the sample for which p1! value is to be found out.

10. Directly record the reading from the meter without doing any adjustments.

Environmental significance

pH (6.5 to 8.5) has no direct effect on health however a lower value below 4 will produce sour taste and higher value above 8.5 a bitter taste. Higher values of p1-I have scale formation in water heating operators and also reduce the germicidal potential of chlorine. High pH induces the formation of trihalomethanes which are causing cancer in human beings.

pH below 6.5 starts corrosion in pipes, thereby releasing toxic metals such as zinc, lead, cadmium & copper etc., According to BIS water for domestic consumption should have pH between 6.5 to 8.5

Application of pH data in environmental engineering practice

1. Determination of pH is one of the important objective in biological treatment, if the pH goes below 5 due to excess accumulation of acids, the process is severely affected. Shifting of pH beyond 5 to 10 upsets the aerobic treatment of the waste waters. In these circumstances, the pH can be adjusted by addition of suitable acid or alkali to optimize the treatment of waste water.

2. Its range is of immense value for any chemical reaction. A chemical value shall be highly effective at particular pH. Chemical coagulation; disinfection, water softening and corrosion control are governed by pH adjustment.

3. Dewatering of sludges, oxidation of cyanides and reduction of hexa covalent chromium in to trivalent chromium also need a favorable range 4. It is used in the calculation of carbonate, bicarbonate, C02 calculation, stability index and acid- base equilibrium.

Ex No: 3 Optimum Coagulant Dosage by Jar Test

Aim:

To determine the optimum dosage of coagulant required for a given sample of waste water.

Apparatus Required:

1 .Laboratory flocculator with stirring paddles

2. Glass Jars

3. Analytical balance

Reagents Required: Alum

Theory:

The amount of coagulant required for coagulation depends on the turbidity of the waste water. The use of optimum amount of coagulant is indicated by the formation of the large feathery flakes. This can be approximately determined in the laboratory by Jar test. The test involves rapid mixing to disperse the chemicals (coagulants) in the sample and slow mixing for the floc formation.

PROCEDURE:

1. Fill 1 litre waste water sample in each of the six jars.

2. Attach the sample jars to the stirring device by lifting he paddles in the right upward direction.

3. Add coagulant (Alum) in progressive dosages into the series of the six sample jars.

4. The coagulant dosage can be selected randomly depending on the characteristics of waste water.

5. Mix the sample rapidly for about 10 mm with mechanically operated paddles at 180rpm followed by gentle stirring about 10 mm. at 30—40 rpm.

6. Remove the jars from the stirring device after stirring is completed.

7. Let the sample in the jars stand for 30 mm. for settling of floc.

8. The dose of coagulant versus floc formation is plotted as graph.

9. The dose of coagulant which gives the best floc is the optimum dose of coagulants.

Ex No : 4 DETERMINATION OF RESIDUAL CHLORINE

Aim

To determine the residual chlorine for the given water sample

Apparatus Required

I. Burette with stand, tiles
II. Pipette
III. Conical flask

IV. Beaker
V. Glass funnel
VI. Measuring jar

Principle

Chlorine combines with water to form Hypochlorous and Hydrochloric acids. In water chlorine, hypochiorous acid and hypo chlorite ions are referred as free chlorine residuals and the chloramines are called combined chlorine residuals.

The chlorine demand of water is the amount of chlorine that must be supplied to leave a desired free combined or total residual after a specified contact period.

The starch iodide test is an age old method for testing the total chlorine residual in a given water sample and is still being used, depending upon the oxidizing power of free and combined chlorine to convert iodide ion to free iodide. This free iodine liberates iodine ions when titrated with sodium thiosulphate.

Reagents Required

Chlorine water I gmL / Acetic Acid

Standard N/40 Sodium thiosulphate solution Starch indicator

Reagents Preparation:

Starch Indicator:

Weigh I g of starch and make it into a paste with 10 ml of hot water and dilute it to 100 ml.

Standard N/40 Sodium Thiosulphate solution:

Dissolve 1.575 gm of $NaS2O3$ in distilled water and make up to 1 litre.

Procedure

1. Take 25 ml of given water sample in a conical flask.

2. Add a small crystal of KI and distilled water to the above flask containing water sample, to make 1 00m

3. Add about 0.5 ml conc.HC1 or about 100ml acetic acid to act as buffer to reduce the pH to a low value between 3.5 to 4.2 to avoid conversion of Cl2 into HOCI and OCL-

4. Titrate the above yellow coloured iodine solution against standard Sodium thio sulphate till yellow becomes light or faintly yellow.

5. Add 1 ml of soluble starch solution (end point indicator) to change the colour from light yellow to blue in the conical flask.

6. Continue the titration with standard sodium thiosulphate till the blue colour just disappears.

7. Note. down the total amount of titrant used in the entire titration. Let it be x ml.

8. Repeat the titration with distilled water as sample and determine the amount of sodium thiosuiphate .let it be y ml.

Environmental significance

The residual chlorine is the measure of chlorine left in water after the required contact period, which will ensure complete killing of bacteria and oxidation of the — organic matter. Usually a free chlorine residue of 0.2 to 0.3 mg/L after a contact period of 10-20 minutes is considered to be sufficient and satisfactory to take care of the future contamination of water to be supplied through the distribution system.

Ex. No: 5 DETERMINATION OF HARDNESS

Aim

To determine the total hardness present in the given sample

Apparatus Required

Burette, Pipette, Conical flask, measuring jar

Chemicals Required

Eriochrome Black-T (EBT) indicator, Ammonium chloride, Ammonium solution, EDTA

Reagents Preparation

EBT indicator

Dissolve 0.2 g of pure solid in 15 ml of distilled water Standard EDTA Titrant

Take 0.5 g of EDTA. Heat it to 80oC for half an hour and cool it. Take 0.37 g of the dissolve and add to get distilled water to make 100ml.

1 ml of exactly 0.02 N EDTA1mg of CaCO3 Ammonia Buffer solution

Dissolve 0.7 g of ammonium chloride (NH4C1) in 5.7ml concentrate ammonia solution and dilute to 100 ml.

Procedure

1. Take 20 ml of the sample in a conical flask.

2. Add 2ml of ammonia buffer to the flask.

3. Add 5 — 6 drops of EBT indicator to the flask wine red colour will be developed.

4. Titrate it with standard EDTA solution which is filled in the burette till the colour changes from wine red to blue.

5. Repeat steps I to 4 for different samples with varying hardness and also for distilled water (blank)

6. For determination of non-carbonate hardness the sample is to be boiled for 30 minutes. The procedure is the same as above.

Sanitary Significance

Hard water has adverse action with soap since it allows less formation of leather. If hard water is used in boilers, scaling problem occurs leading to the bursting of boilers, It makes food tasteless. It affects the working of dyeing process. It is also precipitate protein of meat and make tasteless.

Application of Hardness data in Environmental Engineering Practice

1. Hardness of water is important in determining the suitability of water for domestic and industrial uses.

2. The relative amounts of calcium and magnesium hardness, carbonate and non- carbonate hardness present in water are the factors while determining the most economical type of softening process.

3. Determination of hardness serve as a basis for routine control of softening process.

Ex No: 6 Determination of chloride .

Aim

To determine the amount of chloride present in the given sample

Apparatus required

Burette with stand, pipette, conical flask measuring jar etc.,

Chemicals Required

Sodium Chloride, Silver nitrate, Potassium Chromate

Reagents preparation

Silver Nitrate Solution

Dissolve 1 .2g of silver nitrate in distilled water and make up to 250 ml. Sodium chloride Solution (O.028N)

Dissolve 0.1 648g of sodium chloride in distilled water and make up to 100ml.

Potassium Chromate Solution (K2CrO4)

Dissolve 1 gm of potassium chromate in 20m1 of distilled water.

Procedure

Standardization of Silver Nitrate Solution

1. Pipette 20 ml of sodium chloride solution in to the conical flask. 2.Add one or two drops of potassium chromate solution.

3. Titrate against Silver Nitrate solution until the appearance of reddish brown colour

4. Re peat the titration for concordant values.

Silver Nitrate Vs Sample -

1. Pipette 20 ml of sample in the conical flask.

2. Add one or two drops of potassium chromate solution

3. Titrate against silver Nitrate solution until the appearance of reddish brown colour.

4. Repeat the titration for concordant values.

Environmental Significance of Chlorides

Chloride associated with sodium exerts salty taste, when its concentration is more than 250 mg/1 .There is no known evidence that chloride- constitute any human health hazard. For this reason, chlorides a re generally limited to 250 mg/L in supplies intended for public use. In many areas of world where water supplies are scarce, sources containing as much as 2000mg/L are used for domestic purposes without the development of adverse effect once the human system becomes adapted to the water.

It can also corrode concrete by extracting calcium in the form of calcide. Magnesium chloride in water generates hydrochloric acid after heating which is also highly corrosive and create problems in boilers.

Application of chlorides data in environmental engineering practice

1. Chlorides determination in natural waters is useful in the selection of water supplies for human use.

2. Chlorides determination is used to determine the type of desalting operators to be used.

3. The chloride determination is used to control pumping of ground water from locations where intrusion of sea water is a problem.

4. Chlorides interfere in the determination of COD a correction must be made on the basis of the amount of chloride present. -

Ex No : 7 TURBIDITY

Aim

To find out the turbidity of the given sample.

Principle:

When light in passed through a sample having Suspended particles, some of the light in Scattered by the particles. The scattering to the light is generally proportional to the turbidity. The turbidity of sample is thus measured from the amount of light scattered by the sample, taking a reference with standard turbidity suspension.

Apparatus Required:

Nephelometersturbidimeter, Sample tubes.

Reagents Preparation

1. Dissolve 1.0gm Hydrazine sulphate and dilute to 100ml

2. Dissolve 10gm Hexa methylene Tetra min& and dilute in l00ml

3. 5ml of each of the above solution (1 and 2) in a l00ml volumetric flask and allow to stand for 24 hrs at 25±3°C and dilute to l000ml. This solution has a turbidity of 40NTU.

Procedure:

1. The Nephelometerturbidimeter in switched on and waited for few minutes till it warms up.

2. The instrument is set up with a 4ONTU standard suspension

3. The sample is thoroughly shaked and kept it for sometimes so the air bubbles are eliminated

4. The sample is taken in Nephelometer sample tube and the sample is put in Sample chamber and the reading is noted directly.

5. The sample is diluted with turbidity free water and again the turbidity is read.

Environmental Significance

Turbidity is objectionable because of

a. Aesthetic considerations and

b. Engineering considerations

When turbid water in a small, transport container. such as drinking glass is help up to the light, an aesthetically displeasing opaqueness or ȝmilky coloration is apparent. The colloidal material which exerts turbidity provides adsorption sites for chemicals that may be harmful or

cause undesirable tastes and odours & for biological organism that may be harmful. Disinfections of turbid water is difficult because of the adsorptive characteristics of some colloids and because the solids may partially shield organisms from disinfectant.

In natural water bodies, turbidity may impart a brown or other colour to water and may interfere with light penetration and photosynthetic reaction in streams and lakes.

Turbidity increases the load on slow sand filters. The filter may go out of operation, if excess turbidity exists.

Application of Turbidity Data in Environmental Engineering Practice: Turbidity measurements of particular importance in the field of water supply. They have limited use in the field of domestic and Industrial waste treatment.

1. Knowledge of the turbidity variation in raw water supplies along with other information is useful to determine whether a supply repairs Special treatment by chemical coagulation and filtration before it may be used for a public water supply.

2. Turbidity measurements are used to determine the effectivness of the treatment produced with different chemicals and the dosages needed.

3. Turbidity measurements help to gauge the amount of chemicals needed from day- today in the operation of water treatment works.

4. Measurement of turbidity is settled water prior to filtration is useful in controlling chemical dosages so as to parent excessive loading or rapid sand filters.

5. Turbidity measurements of the filtered water are needed to check o faculty filter operation.

6. Turbidity measurements are useful to determine the optimum dosage of coagulants to treat the domestic and Industrial wastes.

7. Turbidity determination is used to evaluate the performance of waste treatment plants.

Ex No: 8 DETERMINATION OF AVAILABLE CHLORINE IN BLEACHING POWDER

Aim:

To determine the available chlorine percentage in a given sample of bleaching powder

Theory:

In order to work out the disinfecting power of bleaching powder and its requirement for treating given water having a particular chlorine demand, we have to work out the chlorine content in the given bleaching powder.

Reagents Preparation:

Starch Indicator:

Weigh 1 g of starch and make it into a paste with 10 ml of hot water and dilute it to 100 ml.

Standard N/40 Sodium thiosuiphate solution:

Dissolve 1.575 gm of Na2S2O3 in distilled water and make up to 1 litre.

Procedure:

1. Take 0.7 gm of bleaching powder in to a beaker.

2. Thoroughly mix the powder with distilled water in the beaker and pour the solution with several rinsing into a 200m1 volumetric flask.

3. Fill the 200m1 flask with distilled water up to the mark, as to make the chlorine solution equal to 200ml.Mix thoroughly.

4. Dissolve about 2 gm of potassium iodide and 2ml of glacial acetic acid in 2ml of distilled water in a conical flask.

5. Pipette out 25ml of the chlorine solution from the volumetric flask and add it into the above flask containing iodide acetic acid mix.

6. Add a few drops of starch indicator to the conical flask to develop blue colour.

7. Titrate this blue solution in the conical flask against the sodium thiosuiphate solution, till the blue colour in the flask just disappears.

8. Note down\the ml of sodium thiosulphate solution used in the above titration. It may be averaged out by performing the above test twice or thrice. Let this value be Xml.

Ex No: 9 TOTAL, FIXED AND VOLATILE SOLIDS

Aim:

To determine the amount of total, fixed and volatile solids present in the given sample.

Apparatus Required:

Crucible, Chemical balance, hot air oven, muffle furnace, desicator

Procedure:

1. Take the empty crucible. Clean it thoroughly and make it perfectly dry. Take the weight of empty crucible.

2. Add to the crucible 20m1 of liquid sample.

3. Heat the crucible in water bath at 100°C till the entire liquid in a crucible evaporates and dry residue remains at the bottom then place the crucible in oven at 103°C for I hour.

4. Take the weight of the crucible with residue after cooling it in a desicator for 20 minutes. Let us weight be W2 gm.

5. Take the sample crucible and keep it in a muffle furnace at a temperature of 650oC for 30mm

6. The volatile and organic matter in the solids evaporated and the crucible contains only fixed solids.

7. Cool the crucible in a desicator and weight it with the fixed solids residue. Let the weight be W3gm

Environmental Engineering Significance:

The water which contains of high volatile solids is not suitable for drinking purposes. The result of high volatile solids indicates that the water may have been pollutes by domestic waste or other organic waste. In general, ground water is free from volatile solids unless they have been polluted by waste seepages. But, well water may have high volatile solids due to lack of proper protection around well to prevent seepage of used water. Surface water may also have high volatile solids due to disposal of domestic and other wastes.

Application in Environmental Engineering Practice:

- Volatile solids test is normally applied to sludges.
- It is indispensable in the design operation of sludge desicator, vacuum filter and infiltration plants.
- Before the development of C.O.D. test it is used to find the strength of industrial and domestic waste water.
- It is helpful in accessing the amount biologic ally inert organic matter, such as lignin in the case of wood pulping waste liuor.

Ex No: 10 Suspended and Dissolved Solids

Aim:

To determine the amount of dissolved solids present in the given sample.

Apparatus Required:

Crucible, oven, desicator, chemical balance.

Procedure:

1. Take a known quantity of liquid sample in a crucible of known weight.

2. The sample is filtered through watt man paper number 44.The dissolved solids go in solution through the filter paper.

3. Take a known quantity of filtered solution in a crucible of known weight and dry it to a temperature of 103°C to 105°C.

4. Cool the crucible in a desicator and weigh it let the weight be W2gms. /

Environmental Significance:

Water with high dissolved solids generally is of inferior polatibility and makes it use an unfavorable physiological reaction in a transit consumer.

Suspended Solids containing much organic matter make as purification and consequently this may be dividing of dissolved oxygen loading to destruction of plant and human life.

Application:

Dissolved solids determination gives and idea about the formation of scales cause of foaming in boilers, acceleration of corrosion and interference with the colour and taste of many finishes products.

The suspended solid determination is particularly useful in the analysis of sewage and other waste water. It is used to evaluate the strength of waste water and to determine the efficiency of treatment units.

Ex No: 11 TOTAL SETTLABLE SOLIDS

Aim:

To find out the total settlable solids of the given sample.

Apparatus Required:

Imhoff cone, holding device

Procedure:

1. The imhoff cone is gently filled with the thoroughly well mixed sample usually 1 litre and allowed it to settle.

2. After 45 minutes, the cone is rotated between hands to ensure that all solids adhering to the sides are loosened.

3. The solids are allowed to settle for 15 mm more to make up for a total period of 1 hour.

4. The volume of the sludge which has settled in the open is noted.

5. The results are expressed in ml settlable solids per litre of sample per hour.

Precautions:

1. The imhoff cones must be cleaned with a strong soap and hot water using a brush.

2. The cone is wetter before use, which helps in preventing adherence of the solids to the sides.

3. The method is subjected to considerable in accuracy if the solids contain large fragments.

4. The determination of total settle able solids should be carried out soon after sampling in order to avoid errors through flocculation.

Application:

1. The settlable solids determination is used extensively in the analysis of industrial waste to determine the need for and design of plain settling tank in plants employing biological treatment process.

2. It is also widely used in waste water treatment plant operation to determine the efficiency of sedimentation tanks.

Ex No: 12 DETERMINATION OF DISSOLVED OXYGEN

Aim:

To determine the amount of Dissolved Oxygen present in the given sample.

Apparatus Required:

Burette with stand ,pipette,conicalflask,measuring jar

Chemicals Required:

Sodium Hydroxide, Manganous Sulphate, Potassium iodide, Sodium Thiosuiphate, Conc.H2SO4, Starch

Reagent Preparation:

1. Manganous Sulphate:

12 gms of Manganous Sulphate is dissolved in 25m1 of distilled water.

2. Alkaline —Iodide Solution

9 gms of Sodium Hydroxide and 2.5gms of Potassium iodide are dissolved in 25m1 of distilled water.

3. Sodium thiosulphate Solution (O.O1N)

2.48gms of Sodium thiosulphate is dissolved in 1 litre of water.

4. Starch Solution

Take 1 gm of starch. Prepare paste with distilled water. Make 100 ml with water and boil by stirring and cool it.

5. Pipette Solution:

2m1 of Manganous Sulphate solution and 2ml of alkaline Iodide Solution is added to 250m1 of the sample taken in a reagent bottle. The bottle is stoppered and shaken thoroughly when the precipitate formed is settled, 2ml of Cone. HCL or Conc. H2S04 is added and shaken thoroughly until the precipitate gets dissolved completely.

Procedure:

1. Take 50ml of clear pipette solution in a conical flask

2. Add to it one or two drops of starch indicator until the colour becomes blue.

3. Titrate against Standard Sodium Thiosulphate solution until the disappearance of colour.

4. Repeat the titration for concordant values.

Sanitary Significance:

In liquid wastes Dissolved Oxygen is the most important factor in determining whether aerobic or anaerobic organisms carryout biological changes. If sufficient

D.O is available aerobic organisms oxidize the wastes to stable products. If D.O is deficient anaerobic bacteria take part in the conversion and reduce the waste often to obnoxious and nuisance conditions are usually resulted.

Application in Environmental Data:

1. It is one of the most important tests often used in most instances involving stream pollution control.

2. For the survival of aquatic life maintenance of D.O level is a must.

3. Determination of D.O serve as the basis of B.O.D test and thus they are the foundation of the most important determination used to evaluate pollution strength of sewage and industrial waste.

Ex No: 13 ESTIMATION OF SULPHATES

Aim:

To determine the amount of sulphate present in the given sample by gravirnetric method.

Principle:

The sulphate in water is precipitated as Barium Sulphate by the addition of Barium Chloride in hydrochloric acid medium. The precipitated is filtered ,washed free of chloride, ignited and weighed as barium sulphate.

Na2SO4+BaC1---------- .>BaSO4+2NaCl

BaSO4+2C---------- >BaS+2C02

BaS+20---------- >BaSO4

Apparatus Required:

Crucible, Oven, weighing balance, pipette, beaker, water bath, desicator.

Reagents Required:

- Dilute HCL
- Solid Ammonium Chloride 1O%Barium Chloride solution
- Reagents Preparation:
- Barium Chloride Solution:
- Dissolve l0g of Barium Chloride in 100 ml of distilled water.

Procedure:

1. Pipette out 5Oml of sample into a clean 250m1 beaker.

2. Add 1 Omi of dilute HCL & 1gm of solid ammonium chloride.

3. Heat to boiling &add l0ml of 10% Barium Chloride solution drop by drop with constant stirring. Continue boiling for another 2 to 3 minutes.

4. Allow the precipitate to settle and test for completion of precipitation by adding a small amount of Barium Chloride solution through the sides of the beaker.

5. If any turbidity is noticed add sufficient quantity of barium chloride to precipitate all the sulphate.

6. Transfer-the contents to a sand bath &digest for half an hour to promote granulation of the precipitate.

7. Filter through Waliman no 42 filter paper and wash with boiling water till the filtrate runs free of chlorine.

8. Transfer the filter paper along with the precipitate to a weighed silica crucible and dry it an air oven.

9. Ignite over a low flame initially, taking care to ash the filter paper completely, then ignite strongly over a rose head flame to constant weight.

10. From the weight of Barium Sulphate obtained calculate the Sulphate content of the sample.

Environmental Significance:

Sulphates in natural waters in concentrations ranging from a few to thousand mg/L.Excess Na2SO4 and MgSO4 should not be present in drinking waters as they cause Cathartic action. Higher Concentration of Sodium Sulphate in water can cause malfunctioning of the alimentary canal. So the recommended upper limit is 250m/l in water intended for human consumption. In anaerobic decomposition of waste waters, Suiphates are reduced to hydrogen

Sulphide causing obnoxious odours and promote corrosion of sewers.Sulphates are reduced to sulphide in sludge digesters and may upset the biological process, if the sulphide concentration exceeds 200mg/L.

Application of Sulphate Data in Environmental Engineering Practice:

1. The sulphate content of natural waters is an important consideration in determining their suitability for public and industrial water supplies.

2. The amount of sulphate in waste water is a factor of concern in determining the magnitude of problems that can arise from reduction of sulphates to hydrogen sulphide.

3. A knowledge of the sulphate content of the sludge or waste fed to digestion units provides a means of estimating the hydrogen sulphide content of the gas produced. From this information, the design engineer can determine whether scrubbing facilities will be needed to remove hydrogen sulphides and size of the units required.

Ex No: 14 DETERMINATION OF FLUORIDES

Aim:

To determine the fluorides present in the give sample.

Apparatus Required:

Burette with stand, Pipette, Conical flask, measuring flask.

Chemical required:

Oxalate, concentrated hydrochloric acid, phenolphthalein indicator, sodium hydroxide.

Reagents Preparation:

Oxalate Solution:

Dissolve 630mg of oxalate in distilled water and make up to l00ml.

Phenolphthalein indicator:

Add ig of phenolphthalein in 200 ml distilled water and dissolve it. Add 0.02N Sodium hydroxide solution drop wise until a faint pink colour appears.

Sodium hydroxide solution:

Dissolve 4g of sodium hydroxide in distilled water and make up to 100ml.

Procedure:

Titration — I NaoHVs Oxalic acid

1. Pipette 20m1 of oralic acid solution into the conical flast.

2. Add one or two drops of phenolphthalein indicator.

3. Titrate against sodium hydroxide solution until the appearance of pink colour.

4. Repeat the titration for concordant values.

Titration —II NaoHVs Sample:

1. Take 19m1 of sample in the conical flask and add 1 ml of concentrated hydrochloric acid.

2. Add one or two drops of phenolphthalein indicator.

3. Titrate against sodium hydroxide solution until the appearance of pink colour.

4. Repeat the titration for concordant values.

Environmental Significance Fluorine in Human health

Presence of large amount of fluoride is associated with dental and skeletal fluorisis (>1.5 mg/i) and in adequate amounts with dental caries (<I ing/i)

Dental Fluorosis

In young children the diseases affects only on the teeth. This is known as dental fluorosis.The teeth lose their shiny appearance and chalk-white patches develop on them . This is known as mottled enamel and is an early sign of dental fluorisis.The white patches later become yellow and turn brown or black.

Skeletal Fluorosis

Inn aged people the disease affects the bones, tendons and ligaments. This is known as skeletal fluorosis.This is followed by pain and stiff of the back and later the joints of both limbs and limitation of neck movements.

Genu Valgum

It was observed that this syndrome was most prevalent among people whose staple diet was sorghum. Further studies have shown that diets based upon jower promote a higher retention of ingested fluoride than their based on rice.

Application of fluoride data in Environmental Engineering Practice:

1. Fluoride of water is an important in determining the suitability of water from domestic and industrial uses.

2. The size and design of Deflouridation units depends upon the level of fluorides present in the water.

Ex.No:15 DETERMINATION OF AMMONIACAL NITROGEN

Aim:

To determine the ammoniacal nitrogen present in the givJsamp1e.

Apparatus Required:

Burette with stand, Pipette, Conical flask, measuring flask.

Chemical required:

Oxalate, concentrated hydrochloric acid, phenolphthalein indicator, sodium hydroxide, ammonia solution.

Reagents Preparation: Oxalate Solution:

Dissolve 630mg of oxalate in distilled water and make up to l00ml.

Phenolphthalein indicator:

Add 1g of phenolphthalein in 200 ml distilled water and dissolve it. Add 0.02N Sodium hydroxide solution drop wise until a faint pink colour appears.

Sodium hydroxide solution:

Dissolve 4g of sodium hydroxide in distilled water and make up to l00ml.

Standard Hydrochloric acid:

Dissolve 2 ml of HC1 in distilled water and make upto 100 ml.

Procedure:

Titration — I NaoHVs Oxalic acid

1. Pipette 20ml of oxalic acid solution into the conical flask

2. Add one or two drops of phenolphthalein indicator.

3. Titrate against sodium hydroxide solution until the appearance of pink colour.

4. Repeat the titration for concordant values.

Titration —II NaoHVs Ammonia

1. Take l7ml of distilled water in the conical flask and add lml of ammonia solution and 2 ml of hydrochloric acid.

2. Add one or two drops of phenolphthalein indicator.

3. Titrate against sodium hydroxide solution until the appearance of pink colour.

4. Repeat the titration for concordant values.

Calculation:

Titration I

Volume of oxalic acid×Normality of oxalic acid (0.1) Normality of NaOH =

Volume of NaOH

Titration II

Volume of NaOH× Normality of NaOH×0.0091 Normality of Sample X =

Volume of sample

X×Vol of NaOH

Amount of Ammoniacal Nitrogen in mg/L = ×1000 Volume of Sample

Titration — III NaoHVs sample

1. Take 17m1 of distilled water in the conical flask and add 1ml of sample and 2 ml of hydrochloric acid.

2. Add one or two drops of phenolphthalein indicator.

3. Titrate against sodium hydroxide solution until the appearance of pink colour.

4. Repeat the titration for concordant values.

Environmental Significance

I. Excess of ammonia in the form of nitrogen leads to Eutrophication in lakes.

2. Consumption of Nitrogen greater than 2mg/I in drinking water may lead to mathemoglobonemia in children.

APPLICATION

1. Determination of ammoniacal nitrogen used for standardizing the drinking water supply.

2. The data is used in the treatment of waste water before it is subjected to water courses.

3. It is also used to determine the extend of eutrophication and possible methods of removal of Nitrogen.

Ex No: 16 DETERMINATION OF COD

Aim:

To determine the amount of Chemical Oxygen Demand present in the given sample.

Principle:

COD test is widely used for measuring the pollution strength of waste water. All organic compounds with a few exceptions can be oxidized to C02 and water by the action of strong oxidizing agents regardless of biological assimilability of the substances.

Apparatus Required:

1. COD Reactor

2. Burette with stand

3. Pipette

4. Measuring jar

5. Tiles

6. Beakers

7. Conical flask

Chemicals Required:

1. Sid. Potassium dichrornate

2. Conc. Sulphuric acid

3. Ferroin indicator solution

4. Std. Ferrous ammonium sulphate solution

5. Mercuric Sulphate

Reagents Preparation:

Std. Potassium dichromate (0.25 N) solution:

Dissolve 12.26 gm of Potassium dichromate previously dried at 180°C for 2 hr in distilled water and diluted to 1 litre.

Ferroin Indicator Solution:

Dissolve 1 .485 gm of 1, 10 Phenophtholine sulphate monohydrate with 0.695gm of ferrous Sulphate (FeSO4.7H20) in water and dilute to l00ml.

Std.Ferrous Am ‘no ni urn Sulphateî0.25NÒ:

Dissolve 98gm FAS in distilled water and add 20m1 of Conc.H2S04.Cool and dilute to I Iitre.This solution must be standardized against the K2Cr2O7 every day of its use.

Procedure:

1. Take 50m1 of sample in a flask and add boiling chips and 1gm of HgSO4 and 5 ml of H2S04 add slowly to dissolve HgSO4 and cool the mixture.

2. Add 25 ml of 0.25N K2Cr2O7 solution and gain mix. Attach the condense and start the cooling water. The remaining acid agent is added thoroughly through the open end of condenser and the efflux mixture was mixed. Apply the heat and reflux for 2hrs.

3. Dilute the mixture to about 300m1 and titrate excess dichromate with std.FAS using Ferro in indicator.

4. The colour will change from yellow to green to blue and finally red and the ml of titrate was deduced.

5. Reflux on the same manner to a flask consisting of distilled water, equal to the volume of the sample and the reagents titrate as he sample and ml of titrant was deduced.

Environmental Significance:

1. BOD cannot be determined accurately when toxins are present and conditions are un favour for the growth of microbes.

2. BOD test consumes more time i.e a minimum of 5 days where COD test is relatively faster than BOD taking only 3hr for completion.

Application of COD:

1. COD test used extensively in the analysis of industrial wastes.

2. It is particularly valuable in survey system to determine and control losses in sewer system.

3. This Lest is widely used I BOD in the operation of treatment facilities because of the speed with which the result can be obtained.

4. It is useful to access the strength of waste which contains toxins and biological resultant and organic substance.

5. The ratio of BOD to COD is useful to Access the amenability of waste for biological treatment.

6. The ratio of BOD to COD is greater than or equal to 0.8 indicates that the waste water are highly amenable to biological treatment.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lab Manual

Title of Course: MATERIAL TESTING LAB **Course Code: CE795A**
L-T-P scheme: 0-0-3 **Course Credit: 2**

Objectives:

1. The objective of this course is to understand the characteristics and behavior of mechanical engineering materials.
2. Students will learn standard principles and procedure to design prepare and/or test materials.
3. Know how to select materials based on their properties and their proper use for a particular facility under prevailing loads and environmental conditions.
4. Students will have exposure to practical applications including writing of a technical report related to each experiment.
5. To investigate the conventional heat treatment procedures, such as quenching and annealing, used to alter the properties of steels.

Learning Outcomes: The Students will learn standard principles and procedure to design prepare and/or test materials. Know how to select materials based on their properties and their proper use for a particular facility under prevailing loads and environmental conditions

The purpose of this course is to learn the mechanical properties and fundamentals of material testing.
. Upon the completion of material testing lab, the student will be able to:

- **Understand** the characteristics and behavior of mechanical engineering materials. .
- Interpret and quantitatively determine standard mechanical properties.
- Conduct a meaningful hardness, tensile, and impact test and report the test results in a clear and useful manner.
- Determine appropriate tests to be employed to determine given mechanical properties using both destructive and non-destructive techniques.
- Assess and describe the mechanisms leading to failure when provided with a failure example with an unknown cause.
- Ability to analyze heat treatment of carbon steels under different rates of cooling including quenching, and change in hardness and observing its microstructural changes through metallographic studies.

Course Contents:

Experiments that must be done in this course are listed below:
Experiment No.1: Izod impact test.
Experiment No.2: Charpy impact test.
Experiment No 3: Test for drawability of sheet-metals through cupping test.
Experiment No.4: Fatigue test of a typical sample.
Experiment No.5: Sample preparation and etching of ferrous and non-ferrous metals and alloys for metallographic observation
Experiment No.6: Study of heat treatment Processes.
Experiment No.7: Study of non-destructive techniques, such as dye penetration (DP) Test, ultrasonic or eddy-current test.

Text books:

[1] Materials science and engineering: an introduction (7th edition), William D. Callister, Jr., John Wiley and Sons, (2007).
[2] Chandler, H., Heat Treater's Guide, 2nd ed., ASM International, Metals Park, OH, 1995..
[3] Materials Science and Engineering: by Raghavan V.
[4] Dieter, G.E., ***Mechanical metallurgy***, 1988, SI metric edition, McGraw-Hill,

Recommended Equipments/Systems/Software Requirements:

1. Impact testing machine, MS Specimen, cupping test apparatus.
2. Microscope, fatigue test apparatus

EXPERIMENT NO: 1 IZOD IMPACT TEST

Aim: To determine the Impact strength (Specific impact factor) through Izod test.

Principle: Static tests are not satisfactory in determining the resistance to shock or impact loads such as automobile parts are subjected to shock loads, and in the impact test a notched specimen of the material is fractured by a single blow from a heavy hammer, the energy required being a measure of the resistance to impact.

Materials and equipments required

Impact testing machine, MS Specimen

Theory

IZOD Impact Test:

A pendulum type single blow impact test in which the specimen, usually notched, is fixed at one end and free at other end. Specimen is broken by a falling pendulum. The energy absorbed as measured by the subsequent rise of the pendulum is a measure of impact strength or notch toughness.

Notch: A slot or groove of specified characteristics intentionally cut in a test piece so as to concentrate the stress localizing the rupture.

Notch Toughness: The high resistance of the material to fracture under suddenly applied loads at any Stress raiser such as notch.

Toughness: The ability of the material to absorb energy and deform plastically before fracture. It is usually measured by the energy absorbed in a notched impact test like Charpy and Izod tests. The area under the stress - strain curve in a tensile test is also a measure of toughness and as such is proportional to the combined effects of tensile strength and ductility.

The Izod impact energy (I) i.e, the energy required to break the specimen is obtained directly from the test. The depth below the notch and the breadth of the specimen is measured (i.e d and b). The effective cross-sectional area below the notch is obtained ($A=bd\ mm^2$) hence, specific Impact factor=If=I/A Joules /mm^2

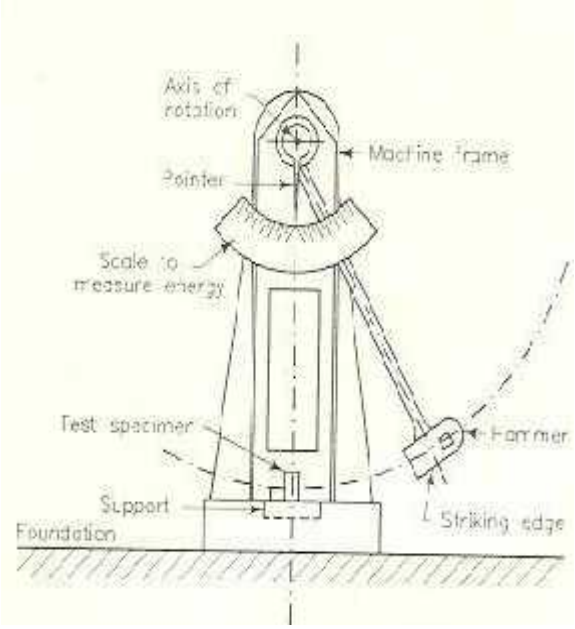


Fig: Izod Impact testing equipment

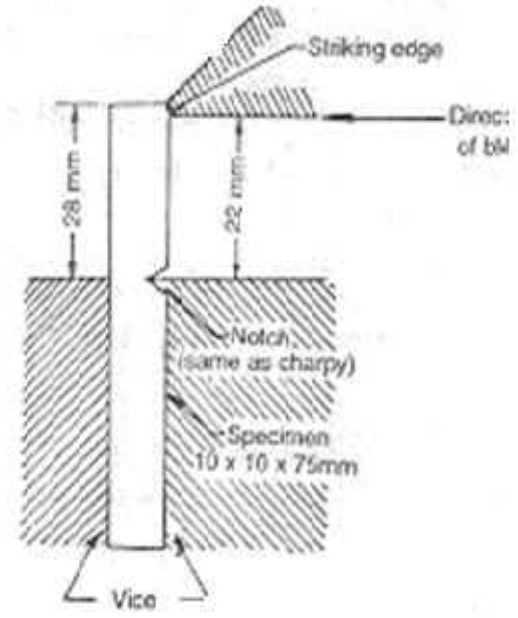


Fig: Position of specimen for Izod test

Tabular Column:

Sl. No.	Specimen	Trials	Initial Reading K1 in J	Final Reading K2 in J	Izod Impact Value K=K1-K2 J	Izod impact Strength I=K/A (J/Cm2)
1	MS	1				
2	MS	2				

Specification
Specimen size= 75*10*10
Type of notch = V- Notch
Angle of notch= 45^o
Depth of notch= 2mm -4mm

Procedure
1. Fix the izod striker in its respective position; place the izod test specimen on supports.
2. Align the centre at the specimen notch with respect to centre of support by means of setting gauge.
3. Touch the striker to the test specimen and adjust the indicating pointer to 170J.
4. Lift the pendulum till it gets latched in its position at 900 from its vertical axis.
5. Allow the pendulum to swing freely and break the specimen.
6. After rupture apply the break to the pendulum slowly by operating break lever.
7. Note down the reading at observed energy directly on the dial as indicated by the indicating pointer.
8. Before proceeding for next test, remove the broken piece of the tested specimen and bring indicating pointer, striker to its original position at 170J.

Results and Conclusion
Average impact value of Mild Steel = ----------Joules
Average impact strength = ----------Joules/cm2

EXPERIMENT NO: 2 CHARPY IMPACT TEST

Aim: To determine the Impact strength (Specific impact factor) through Charpy test.

Principle:
The Charpy Impact Test is similar in principle to the Izod, but the notched specimen is supported at each end as a beam and struck by the hammer in the centre.

Materials and equipments required:

Impact testing machine, MS Specimen

Theory

In an impact test a specially prepared notched specimen is fractured by a single blow from a

produced by a swinging of an impact weight (hammer) from a height. Release of the weight from the height swings the weight through the arc of a circle, which strikes the specimen to fracture at the notch. Here it is interesting to note that height through which hammer drops determines the velocity and height and mass of a hammer combined determine the energy. Energy used can be measured from the scale given. The difference between potential energies is the fracture energy. In test machine this value indicated by the pointer on the scale. This energy value called impact toughness or impact value, which will be measured, per unit area at the notch.

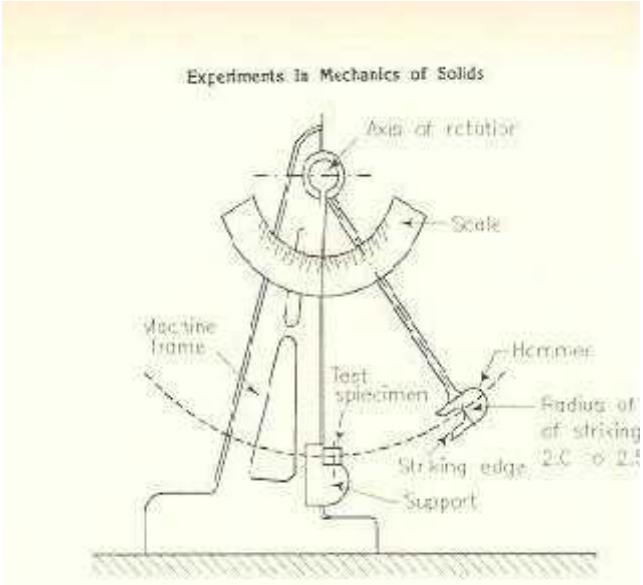
Specification

Specimen size= 55*10*10

Type of notch = U - Notch

Angle of notch= 45^{o}

Depth of notch= 2mm-5mm



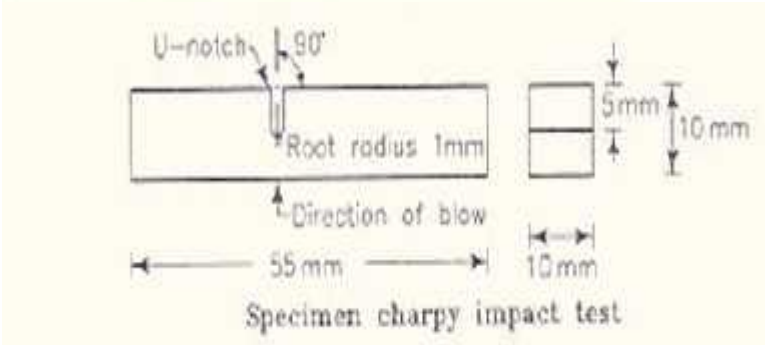


Fig: Charpy impact testing equipment **Fig: Specimen for Charpy test**

Tabular Column:

Sl. No.	Specimen	Trials	Initial Reading K1 in J	Final Reading K2 in J	Charpy Impact Value K=K1-K2 J	Charpy impact Strength I=K/A (J/Cm2)
1	MS	1				
2	MS	2				

Procedure

1. Fix the charpy striker in its respective position; place the charpy test specimen on supports.

2. Align the centre at the specimen notch with respect to centre of support by means of setting gauge.

3. Touch the striker to the test specimen and adjust the indicating pointer to 300J.

4. Lift the pendulum till it gets latched in its position at 1400 from its vertical axis.

5. Allow the pendulum to swing freely and break the specimen.

6. After rupture apply the break to the pendulum slowly by operating break lever.

7. Note down the reading at observed energy directly on the dial as indicated by the indicating pointer.

8. Before proceeding for next test, remove the broken piece of the tested specimen and bring indicating pointer, striker to its original position at 300J.

Results and Conclusion

Average impact value of Mild Steel = ----------Joules

Average impact strength = ----------Joules/cm2

EXPERIMENT NO: 4 Test for drawability of sheet-metals through cupping test
Aim: Test for drawability of sheet-metals through cupping test.

Theory:

1.1 Limiting draw ratio:

In deep drawing, the longitudinal tensile stress on the cup leads to thinning and tearing. There is a maximum size of the blank which can be drawn out without tearing. The limiting draw ratio (LDR) is defined as the highest value of the ratio of the blank diameter

LDR = $(D_0/D_p)_{max} = e^{\eta}$ …..1.1

Where η is the efficiency of drawing.

The maximum LDR for efficiency =100% is equal to 2.7. The above can be proved as followed:

Consider the deep drawing of a cup. The maximum true strain of the blank during deep drawing is:

$$\varepsilon_{max} = \ln\left(\frac{D_0}{D_p}\right)$$

For ideal drawing we can write the draw stress = Yε

For maximum or limiting draw, we can equate the draw stress to yield strength of the material.

Y = draw stress =y ε_{max}

From which we get:

$\varepsilon_{max} = \ln\left(\frac{D_0}{D_p}\right)$ = 1 …….1.3

From the above we get $\frac{D_0}{D_p}$ = e = 2.7 …… 1.4

If we assume an efficiency of 70% the maximum LDR is about 2. That means the maximum reduction possible in single deep drawing step is 50%.

LDR is affected by the punch dia, lubrication, the hold down pressure, and clearance.LDR is also affected anisotropy of the material of the blank. One way of increasing the drawability of sheets is to impart anisotropy through grain texturing. Anisotropic behavior refers to direction dependency of mechanical properties. Normal anisotropy or plastic anisotropy of a sheet metal is given by the ratio of the width strain to thickness strain.

$$R = \frac{ln\ (w0/wf)}{ln\ (t0/tf)}$$ ……1.5

Subscript f denotes final dimension.

If the true strain along width is equal to that along thickness direction R =1. That is the case of isotropic material. On the other hand, if R is very less or higher than unity it indicates considerable anisotropy.

The thickness strains are very difficult to measure. Therefore we may write R using length, applying volume constancy as:

$$R = \frac{\ln(w_0/w_f)}{\ln(w/w)} \qquad \text{…….. 1.6}$$

For rolled sheets, we can consider planar anisotropy, which means the orientation of the test specimen with respect to rolling direction will decide the properties. Planar anisotropy taken at different angles with respect to rolling direction, averaged out is defined as:

$$\bar{R}=\frac{R0+2R4+R9}{4} \qquad \text{……1.7}$$

The average normal anisotropy value depends on the material structure, grain size, etc. Typically, for HCP R values are high. Similarly, finer the grains lower is the value of average anisotropy.

Material	$\bar{R}$
Hot rolled steel	0.8 to 1
Stainless steels	0.9 to 1.2
Aluminium alloys	0.6 to 0.8
Copper	0.6 to 0.9

It has been demonstrated experimentally that as the average normal anisotropy increases, the LDR also increases, almost linearly. It is shown in figure below:

Planar anisotropy of a sheet metal can be given by:

$$R=\frac{R0-2R4+R9}{4} \qquad \text{…….1.8}$$

A low value of planar anisotropy enhances the LDR.

LDR in crystalline materials can be controlled through anisotropy. Anisotropy can be controlled through grain texture. Texture can be imparted through rolling or other thermo-mechanical processing. In plane strain stressing of the cup wall, if textured structure can improve the normal anisotropy, LDR will have increased – meaning that drawability has been enhanced. Planar anisotropy sometimes causes a type of defect in drawn cups called earing. Ears are fold like structures that form along the cup length.

1.2 Redrawing:

Redrawing is reduction in diameter and increase in length of a cup which has been drawn to a certain draw ratio. In case of materials which are difficult to draw in one step, redrawing is performed. Generally, during the first stage upto 40% reduction is achieved. In the first redrawing after drawing, maximum of 30% reduction can be set. In

the second redrawing stage, 16% reduction is set. In direct redrawing process, the angle of bending undergone by the cup is less than 90^{o}, thereby reducing the draw force. In reverse redrawing, the outside surface of the drawn cup becomes the inner surface during redrawing. Wrinkling is controlled to a good extent in this process. Friction is higher in redrawing. Therefore larger reductions cannot be affected in redrawing.

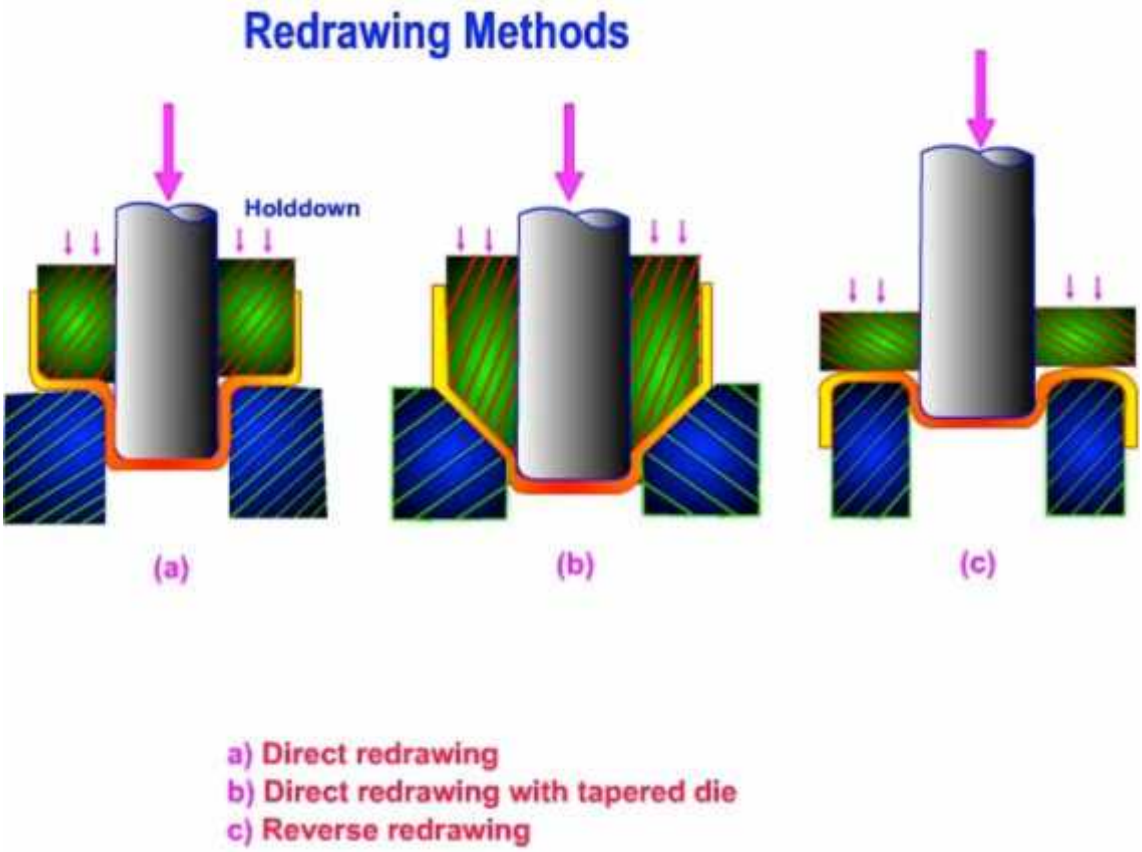


Fig. Redrawing

1.3 Formability of sheet metals:

Formability of sheet metal is the ability of the sheet metal to undergo forming to the desired shape and dimensions, without failure. Sheet metal operations are very complex. Therefore, simple tensile or compressive tests may not be sufficient to evaluate the formability. We can determine the ductility, anisotropy and other parameters from the uniaxial tensile test. A number of other tests have been devised to determine formability of sheet metals. Cupping tests: In order to reflect the biaxial state of stress involved in drawing, a few tests have been devised to obtain the drawability. In Erichsen test a sheet metal is placed on the die cavity and clamped with 1000 kg load. A spherical ball of 20 mm diameter is pressed into the sheet using hydraulic force. The test is terminated at the point of maximum load or until a crack forms on the sheet. Erichsen number is the

distance through which the sheet has stretched. Bulge test: A sheet metal clamped around its periphery, is bulged by hydraulic pressure. The depth of penetration before failure is taken to be a measure of formability. This test is also done to study effective stress-effective strain curve for biaxial stress.

Swift test involves pure drawing, while Fukui test combines drawing and stretching, by using a hemispherical punch which produces a conical cup.

1.4 Forming limit diagram (FLD):

Prediction of failure during drawing is possible by construction forming limit diagrams. Circles of a specific pattern are etched on the surface of the sheet metal, by chemical etching or photo printing. The circles may be 2.5 to 5 mm in diameter. Then the blank is subjected to stretching using suitable punch and draw bead. The deformations of the circles in regions where necking has happened are measured. Lubrication may be used if needed. Major and minor strains on the circles are found from the deformed circle. Circles get deformed into ellipse. If we take a wide rubber plate, draw a circle at the centre and stretch the rubber along longitudinal direction. We can see that the circle now gets stretched to an ellipse. On the other hand, if a circle is drawn on the surface of a spherical balloon and the balloon expanded, the circle becomes a larger circle. This means that both minor and major axes have undergone equal strain.

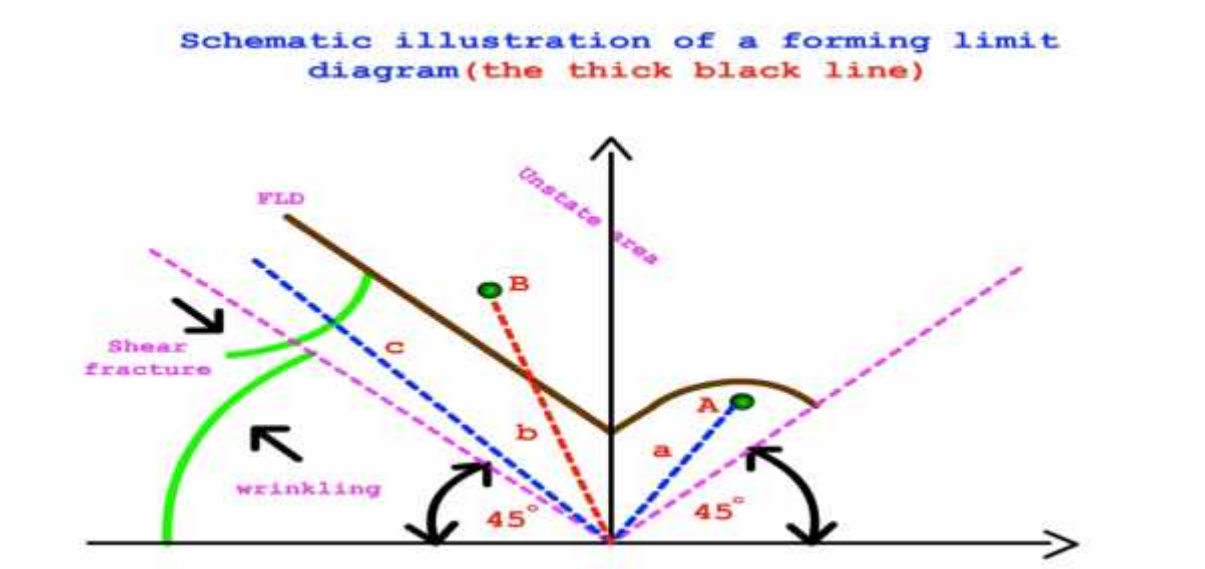


Fig. A typical forming limit diagram

Length of major axis of the stretched circle minus dia of original circle divided by original dia of circle gives the major strain (engineering strain). Similarly engineering minor strain

is negative strain. By comparing the deformed circles, with original circled we can also predict if the sheet has undergone thinning or not. A larger ellipse is an indication of thinning. After a number of such tests, the forming limit diagram is drawn, between major strain and minor strain. The boundary between safe and failed regions is represented in the forming limit diagram. Any strain represented on the diagram by a point lying above the curve indicates failure. The strain path can be varied by varying the width of the sheet. Different materials have different forming limit diagrams. The higher the position of the curve greater is the formability.

A typical formability limit diagram is known as Keeler-Goodwin diagram. The curves shift upward if the sheet thickness is increased – indicating increase in forming limit. In this diagram, a few straight lines indicating the strain paths are also shown. The vertical line at the center (zero minor strain) represents plane strain. In biaxial strain, both strains are equal. This is represented by the inclined line on right side of the diagram. Simple uniaxial tension is represented on the left side by a line with slope 2:1. This is due to the fact that Poisson's ratio for plastic deformation is ½. Negative minor strain means there is shrinkage. It is better to have negative minor strain because; the major strain for failure will be higher with negative minor strain. Some of the factors which affect the forming limit of a material are: strain rate sensitivity, anisotropy, thickness of the sheet, strain hardening etc. The forming limit curve will be shifted upwards for a thicker sheet.

1.5 Hydroforming of sheet metals:

Forming of sheet metals using hydrostatic pressure of a fluid has immense potential for automotive and aerospace applications. Sheet metal products meant for these applications can be formed using hydroforming. Hydrostatic pressure enhances the ductility. Further, it also enhances the LDR. There are two methods of hydrostatic forming of sheet metals, namely hydro-mechanical forming and hydroforming.

1.5.1Hydro-mechanical forming:

In this method of cup drawing, an oil or water chamber underneath the cup contains high pressure fluid. The fluid pressure exerted on the bottom side of the cup ensures that the blank is pressed against the punch, thereby reducing neck formation. The hydraulic pressure also enhances the lubrication between die and blank. This better lubrication improves LDR. If pressurized fluid is supplied onto the edges of the blank, the drawability is further enhanced through reduced friction. Reverse redrawing or redrawing can also be carried out by this process.

1.5.2Hydro-forming:

In hydroforming the fluid pressure is directly utilized for deforming the material. Bulging of tubes is one example for hydroforming. In this process, the high pressure fluid held inside the tube expands the tube at the section where there is no restraint.

1.6Defects in sheet metal formed products:

One of the major defects in drawing of sheet metals is thinning or localized necking, which leads to crack formation or tearing. During cup drawing, material near the punch radius is subjected to maximum thinning and therefore, the bottom of the cup gets separated. Providing large radius on the punch or reducing the punch load may eliminate this defect. Radial cracks in the flange of the cup are an indication of poor ductility of the material. Buckling of the flange material due to high compressive stress leads to wrinkling. The critical circumferential compressive load is lower for thin sheets. We may imagine that each circumferential element of the metal acts like a column subjected to buckling. Increasing the hold down pressure will eliminate wrinkling. Large grain size of sheet metals results in poor surface finish and the surface develops orange peel effect, which is surface roughness. This defect can be prevented using fine grained material for drawing. Surface defects called stretcher strains occur on low carbon steel sheets due to yielding. Depressions form on the surface oriented along directions of maximum shear, namely, 45 degrees. They merge and form rough surface. The entire surface is covered by stretcher strains. Temper rolling or skin rolling treatment given at room temperature will eliminate stretcher strains. In temper rolling, a small cold reduction of 1 to 2% is given to the sheet. Formation of wavy edge on top of the cup, called earing, happens due to anisotropy of the material, especially planar anisotropy. Primarily, preferred orientation of grains is responsible for this defect.

Example 1: A sheet is subjected to tensile stretching during which it undergoes a stretching of 25% and also undergoes decrease in thickness of 12%. What is its limiting draw ratio?

Solution: The limiting draw ratio can be found from the relation between R and LDR.

R = width strain/thickness strain = $\frac{ln\ (w_o/w_f)}{ln\ (t_o/t_f)}$

We are given $L_f/L_o - 1 = 0.25$ or $L_f/L_o = 1.25$

Also, $1- t_f/t_o = 0.12$, Or $t_f/t_o = 0.88$

From volume constancy, $L_o t_o w_o = L_f t_f w_f$

$w_o/w_f = L_f t_f/L_o t_o = 1.25X0.88 = 1.1$

Therefore, R = 0.746

From the graph between R and LDR, we get the LDR for R=0.746, assuming planar anisotropy. LDR = 2.25

……..

EXPERIMENT NO: 4 FATIGUE TEST
Aim: To determine the fatigue failure of a given specimen.

Apparatus: fatigue testing machine, specimen

Theory:

Characteristics of fatigue failure Most engineering failures are mainly due to fatigue in which the components are subjected to fluctuating or cyclic loading such as suspended bridges, rails, or airplane wings. Though the fluctuating load is normally less than the yield strength of the materials, it results in fracture behaviour which is more severe than that achieved from static loading. Fatigue failures are therefore unpredictable, and provide high-risk situations, if the operators are not aware of material behaviour when subjected to fatigue loading. Fatigue failures can be easily observed from its unique characteristics of fracture surfaces, revealing as a beach mark pattern as shown in figure 1 (a). Fatigue failures are also driven by severe environment. For example, corrosion fatigue is a combined situation of fatigue loading in a corrosive environment as illustrated in figure 1 (b).

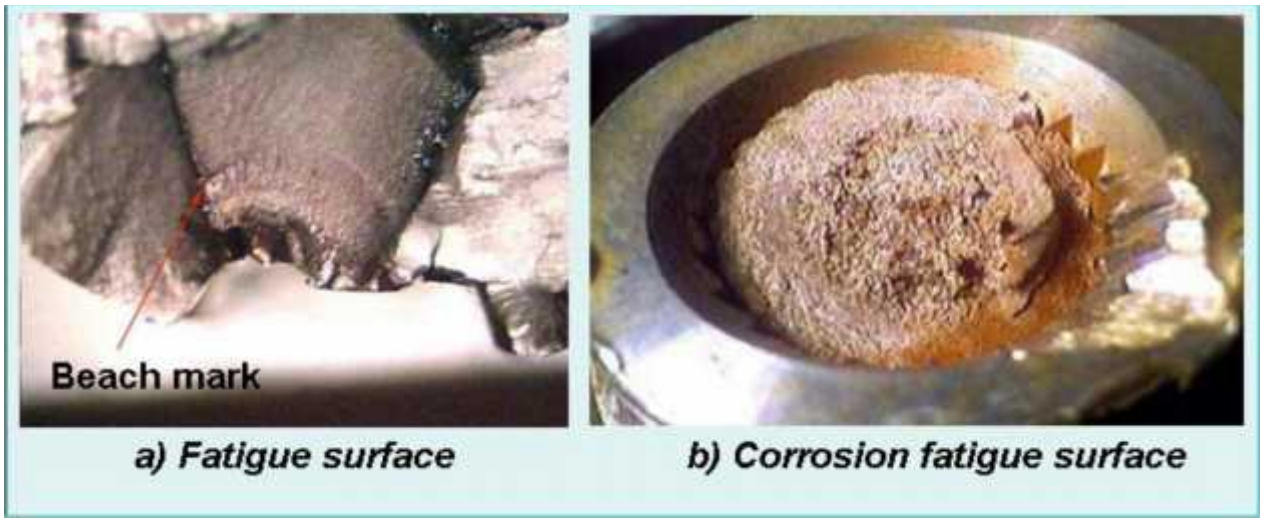


Figure 1: *Fatigue surfaces.*

1.2 Stress cycles and the S-N curve

Cyclic loading in general has no repeated patterns or in situations where overloading occurs as seen in figure 2 (a). However, in order to investigate the fatigue behaviour according to engineering purposes, a simple relation between stress and number of cycles to failure (time) can be expressed in a sinusoidal curve as illustrated in figure 2 (b). Fatigue behaviour of materials can thus be practically described according to the parameters given as follows;

- Maximum stress (σ_{max})

- Minimum stress (σ_{min})

- Stress range ($\Delta\sigma$) = $\sigma_{max} - \sigma_{min}$

- Mean stress = $(\sigma_{max} + \sigma_{min})/2$

- Stress amplitude = $(\sigma_{max} - \sigma_{min})/2$

- Stress ratio = $\sigma_{min} / \sigma_{max}$

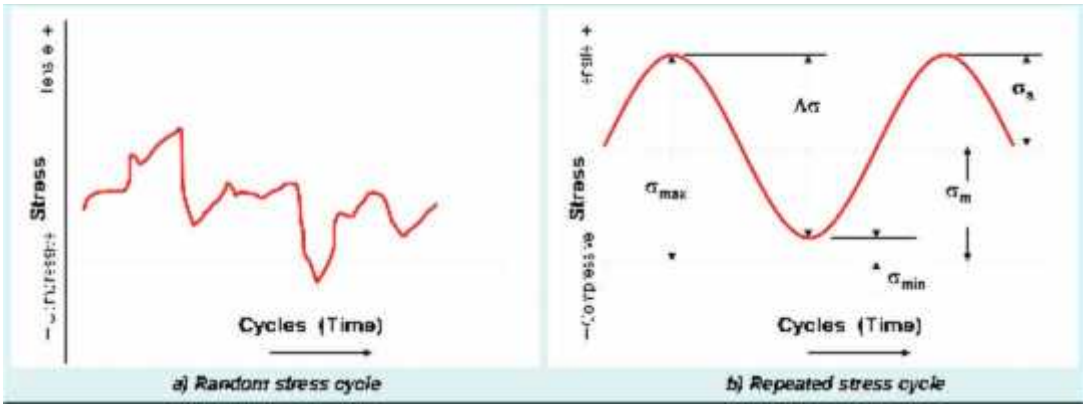


Figure 2: *Relationships between stress and time or no. of cycles.*

These parameters significantly affect the fatigue behaviours of the materials. This is for example, increasing in the maximum stress as well as mean stress and stress range leads to more severe fatigue conditions. If the maximum and minimum stresses are tensile, they are considered to be more dangerous than compressive stresses as the tensile stresses will open up the fatigue crack. Furthermore, if the maximum and minimum stresses are in similar amounts but having the opposite signs (tensile and compressive stresses), the stresses in this case is called completely reversed cyclic stresses in which the stress ratio equals -1. For instance, a rotating-beam fatigue machine as shown in figure 3, fitted with a fatigue specimen hung by a weight in the middle. Specimen rotating action is driven by a motor on the right results in tensile stress in the lower fibrous and compressive stress in the upper fibrous of the specimen gauge length. Therefore, along the gauge length, specimen will be subjected to alternating tensile and compressive stresses similar to the reversed cyclic loading. The specimen will be fatigue loaded until failure. The number of cycles to failure according to the cyclic stress applied will then be recorded.

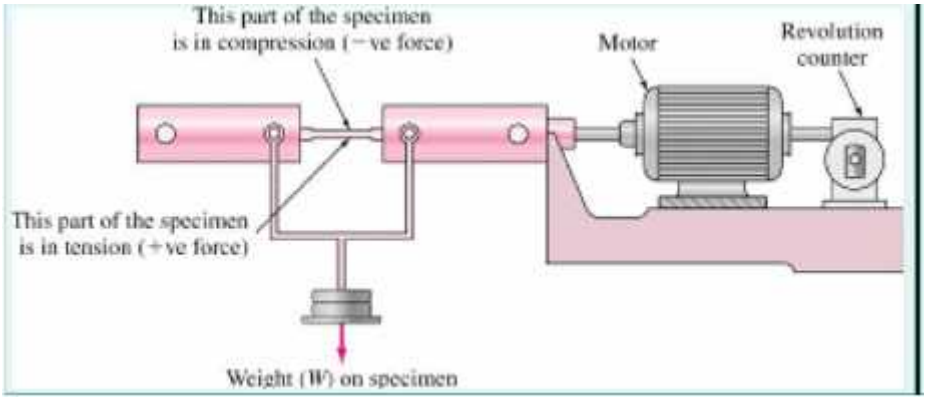


Figure 3: *Rotating-beam fatigue testing machine [2].*

The fatigue testing can also be conducted using an instrument as shown in figure 4. The fatigue specimen is gripped on to a motor at one end to provide the rotational motion whereas the other end is attached to a bearing and also subjected to a load or stress. When

specimen gauge length are subjected to tensile and compressive stresses respectively. Therefore, stress varies sinusoially at any point on the specimen surface. The test proceeds until specimen failure takes place. The revolution counter is used to obtain the number of cycles to failures corresponding to the stress applied.

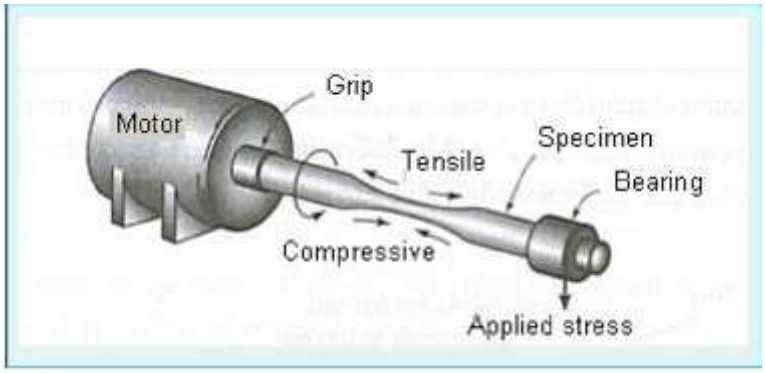


Figure 4: *Fatigue testing machine [3].*

Increasing of the weight applied to the fatigue specimen results in a reduction in number of cycles to failure. We can then use the experimental results to construct an S-N curve as illustrated in figure 5. The fatigue test is normally conducted using at least 8-12 specimens in order to provide sufficient information for the interpretation of fatigue behaviour of the tested material. The S-N curve shows a relationship between the applied stress and the number of cycles to failure, which can be used to determine the fatigue life of the material subjected to cyclic loading. High applied cyclic stress results in a low number of cycles to failure. For example, the fatigue testing of a 1047 steel provides a small number of cycles to failure at a high cyclic stress. As the cyclic stress reduces, the number of cycles to failure increases. At the fatigue endurance limit, there will be a certain value of the cyclic stress where specimen failure will not occur. This cyclic stress level is called the fatigue strength. According to figure 4, the fatigue strength of 1047 steel is approximately 320 MPa. However, nonferrous alloys such as some alloys of aluminium, magnesium and copper will not normally show the fatigue endurance limit. The slope can be found gradually downwards with increasing number of cycles to failure and shows no horizontal line. In such a case, the fatigue strength will be defined at a stress level where the number of cycles to failure reaches 10^7 or 10^8 cycles.

The fatigue strength of engineering materials is in general lower than their tensile strength. A ratio of the fatigue strength to the tensile strength as described in equation 1 is called the fatigue ratio. It is normally observed that, in the case of steels, the fatigue strength increases in proportional to the tensile stress. Therefore, improving the tensile strength by hardening or other heat treatments normally increases the fatigue strength of the mateiral. However for nonferrous metals such as aluminium an alloy, the fatigue ratio is found approximately 0.3 and the improvement of the tensile strength do not necessary increases the fatigue strength of the material.

Fatigue ratio = $\frac{F \quad Si \quad h}{T \quad Si \quad h}$ (1)

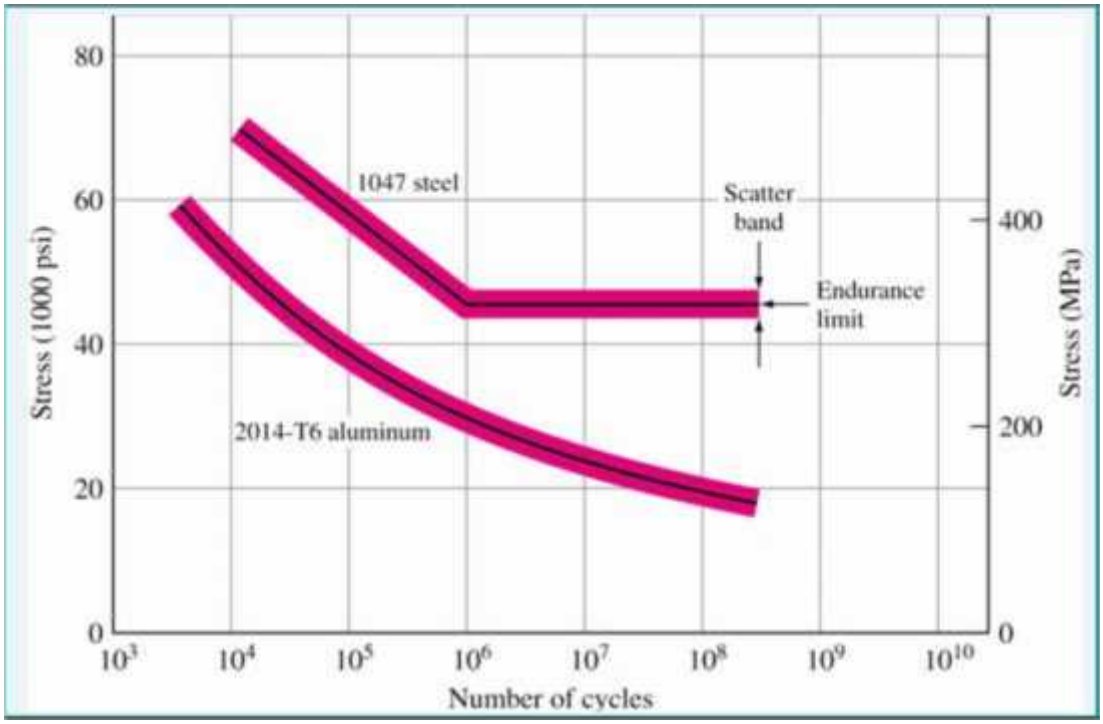


Figure 5: *S-N curves of 1047 steel and 2014-T6 aluminium alloy [2].*

The fatigue S-N curve are generally considered in 2 cases, which are high cycle fatigue and low cycle fatigue. The study of high cycle fatigue concerns about fatigue behaviour of the materials which is controlled by the applied load or stress and where the gross deformation taking place is elastic. However highly localized plastic deformation can also be observed for example at the crack tip. The number of cycles to failure in this case is normally determined at higher than 10^5 cycles. The S-N curve in the high cycle fatigue region can be expressed using the Basquin equation as follow;

$N\,\sigma_a\,p = C$ …(2)

where σ_a is Stress amplitude

p and *C* is Empirical constants

In the case of low cycle fatigue, the fatigue behaviour is controlled by elastic and plastic strains and the number of cycles leading to failure is lower than 10^4 or 10^5 cycles. Gross plastic deformation is due to high levels of the applied stresses and leads to difficulties for stress interpretation. The low cycle fatigue data is generally presented as a relationship between plastic strain ($\Delta\varepsilon_p$) and the number of cycles to failure (*N*) as illustrated in figure 6. When plotted in a log-log scale, the relationship can be expressed following the Coffin-Manson relationship

$\Delta\varepsilon_p/2=\varepsilon_f\,(2N)^c$

where $\Delta\varepsilon_p$ */2* is Plastic strain amplitude

2N is Strain reversal to failure, whereby 1 cycle equals 2 reversals

C is Fatigue ductility exponent, having the values ranging from -0.5 to 0.7.

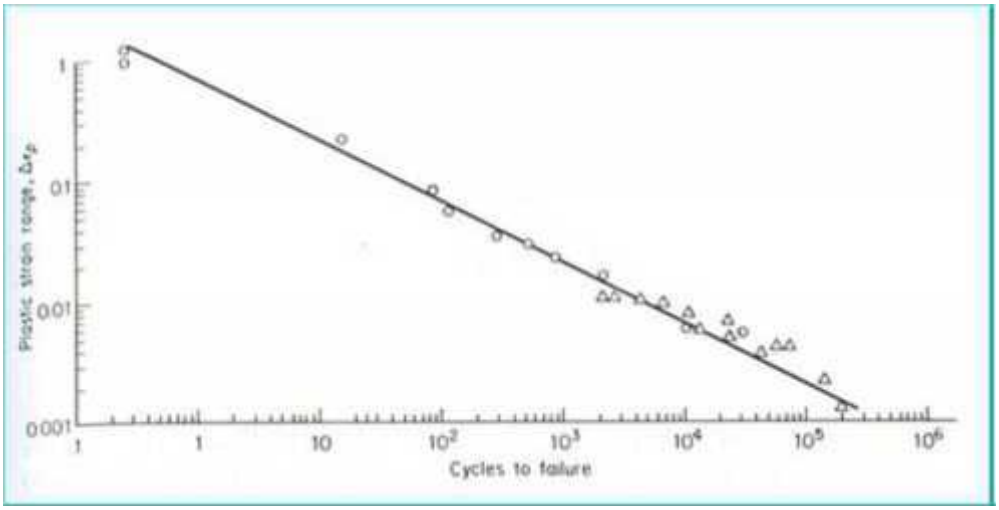


Figure 6: *Low cycle fatigue curve ($\Delta\varepsilon_p$ vs N) 347 stainless steel [1].*

1.3 Cyclic stress-strain curve

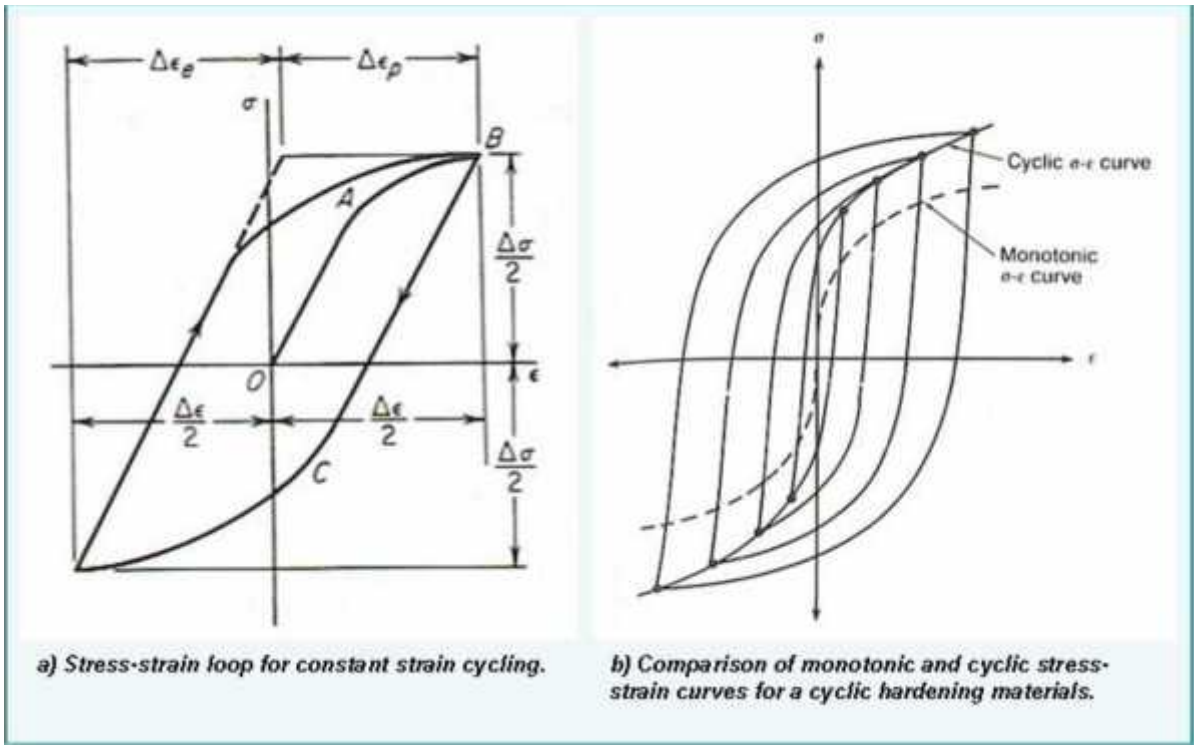
Materials response differently to static and cyclic loading as illustrated from stress-strain relationship. If we first consider figure 7 (a), which shows the stress-strain loop under controlled strain (at constant strain amplitude), the stress-strain relation follows the OAB line when subjected to tensile loading passing the yield point. On unloading, the stress-strain relation follows BC line and goes into the compressive region having a negative strain. It is noticed that the compressive yield is somewhat smaller than that obtained from the tensile yielding. This phenomenon is called the Baushinger effect.Reloading results in a hysteresis loop and gives a total strain $\Delta\varepsilon = \Delta\,\varepsilon_e + \Delta\,\varepsilon_p$ where $\Delta\varepsilon_e$ is the elastic strain range and $\Delta\varepsilon_p$ is the plastic strain range as shown in figure 7 (a).

Furthermore, plastic deformation taking place during cyclic loading causes microstructural changes such as structure and density of dislocations. Therefore, after every cycle applied the material responses slightly differently to the cyclic loading. The material will experience either cyclic hardening or cyclic softening, and both change the shape of the hysteresis loop as illustrated in figure 8.The hysteresis loop generally stabilizes after being cyclic loaded about 100 cycles. Figure 7 (b) demonstrates how materials response differently to static loading and cyclic loading. The former shows a momotonic σ−ε curve whereas the latter provides a cyclic σ−ε curve. This cyclic σ−ε curve is constructed by connecting the tip of the stablized hysteresis loops obtained from a number of fatigue tests at different controlled strain amplitude. Moreover, the cyclic σ−ε curve can also be expressed in a power curve analogy to that obtained from static loading as shown in equation 4.

$\Delta\,\sigma = K\,(\Delta\,\varepsilon_p)^n$

where *n* is the cyclic strain hardening exponent

K is the cyclic strength coefficient



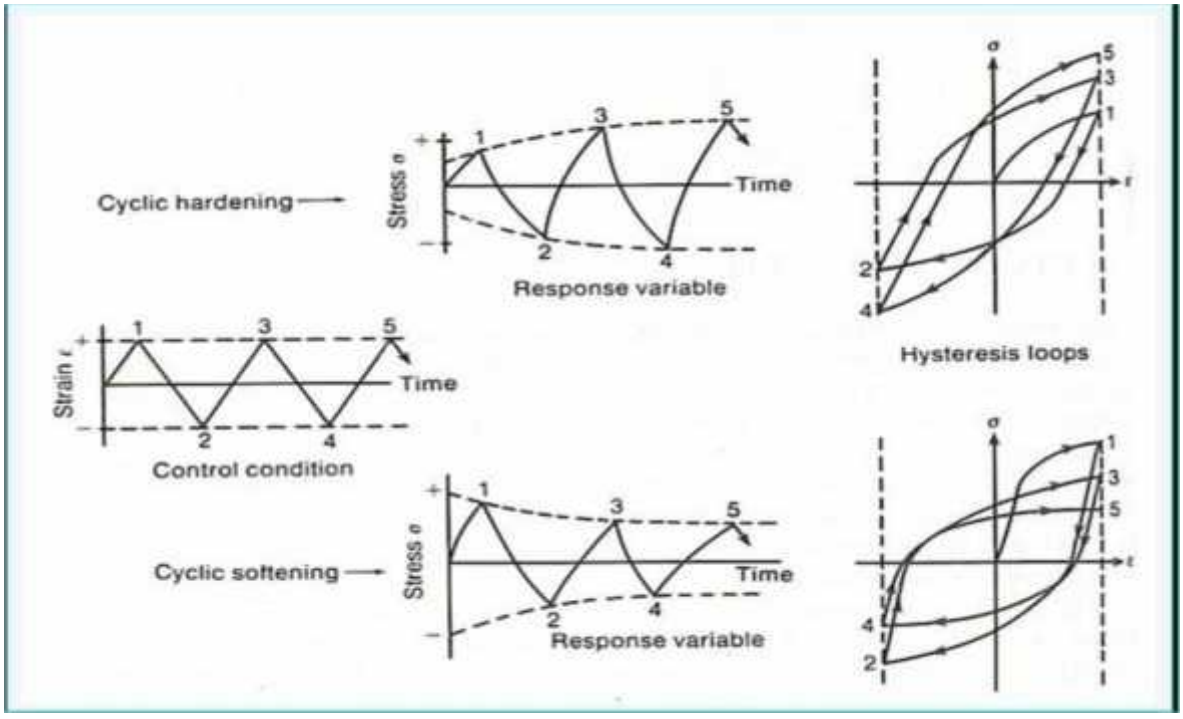
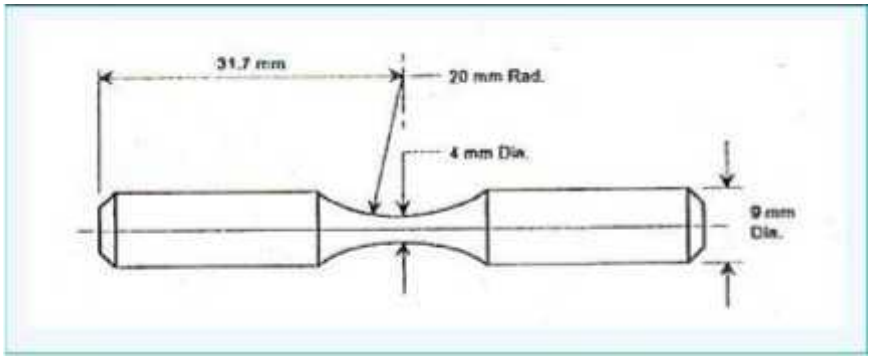


Figure 8: *Responses of metals to cyclic strain cycles [1].*

Factors influencing fatigue properties of materials:

As mentioned previously, characteristics of the applied stresses such as maximum stress, mean stress and stress ratio significantly affects the fatigue behaviour of the materials. However, there are a range of factors which are also found to significantly influence the fatigue properties of engineering materials. These are for example, stress concentration, size effect, surface effect, combined stresses, cumulative fatigue and sequence effect, metallurgical variables, corrosion and temperature. Generally, the fatigue crack initiations

concentration which accounts for further fatigue crack propagation and eventually lead to global failure. Corrosive environment and high service temperatures are reckoned to have negative effects on fatigue properties of the materials as they accelerate faster rates of both fatigue initiation and propagation.



Fatigue specimen

Materials and equipment

1. Fatigue specimens

2 Micrometer or vernier calliper

3 Permanent pen

4 Fatigue testing machine

Experimental Procedure

Measure dimensions of brass and steel specimens provided and record in tables 1 and 2. If the distance from the load end to the minimum diameter of the specimen is 125.7 mm, the bending stress, σ, can be calculated the bending stress for a load *P* (N) is shown in equation $\sigma = 125.7\ 32\ P \times 32 / (\pi \times D^3)$

Conduct the fatigue test at room temperature using the fatigue testing machine as shown in figure. Fit one end of the specimen to a motor and fit the other end to a bearing hung with a known weight, indicating the stress applied to the specimen. Start the motor to rotate the specimen at a constant speed. The revolution counter is used to record the number of cycles to which the specimen fails. Record the result in table 1.

Change the weights used and follow the experiment. Again, record the results in tables 1.

Construct the S-N curves of the steel specimens.

Investigate fracture surfaces of broken fatigue specimen and sketch the result in tables 1.

Analyze, discuss the obtained results. Give conclusions.

4. Results

Details	**Specimen 1**	**Specimen 2**	**Specimen 3**	**Specimen 4**	**Specimen 5**

Specimen diameter (mm)					
Cross-sectional areas (mm2)					
Weight (kg)					
Maximum stress (MPa)					
Frequeny (Hz)					
No. of cycles to failure (cycles)					
Fracture surfaces					

Table 1: *Fatigue data of steel specimens.*

EXPERIMENT NO: 5 Sample preparation and etching of ferrous and non-ferrous metals and alloys for metallographic observation.

Aim: To prepare Sample and etching of ferrous and non-ferrous metals and alloys for metallographic observation

Introduction:

- The credit for originating Metallographic examination goes to Alloys Beck Von Widmanstatten (between 1808 & 1840).
- Microscope was employed for the purpose in 1841, when Paul Annosow used the instrument to examine the etched surfaces of oriental steel blades.
- It was around 1890 when metallographic technique received general recognition, largely as a result of the work of Professor Henry C. Sorby in England.
- *Metallography* is the general study of metals and their behavior, with particular reference to their microstructure and macrostructure.
- *Microstructure* is the characteristic appearance and physical arrangement of metal molecules as observed with a microscope.
- *Macrostructure* is the appearance and physical arrangement as observed with the naked eye.
- *Metallurgical Microscope* is by far the most important tool of the metallurgist from both the scientific and technical stand point. It helps determining:
  a) Grain size and shape.
  b) Size, shape and distribution of various phases and inclusion.
  c) Mechanical and thermal treatment of the alloys.

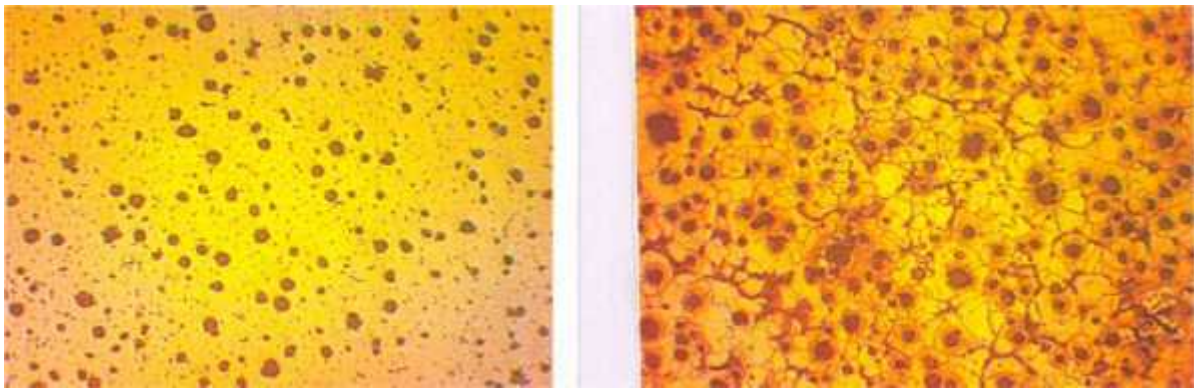
Preparation of Specimen:

Preparation of specimen is necessary to study its microstructure, because the metallurgical

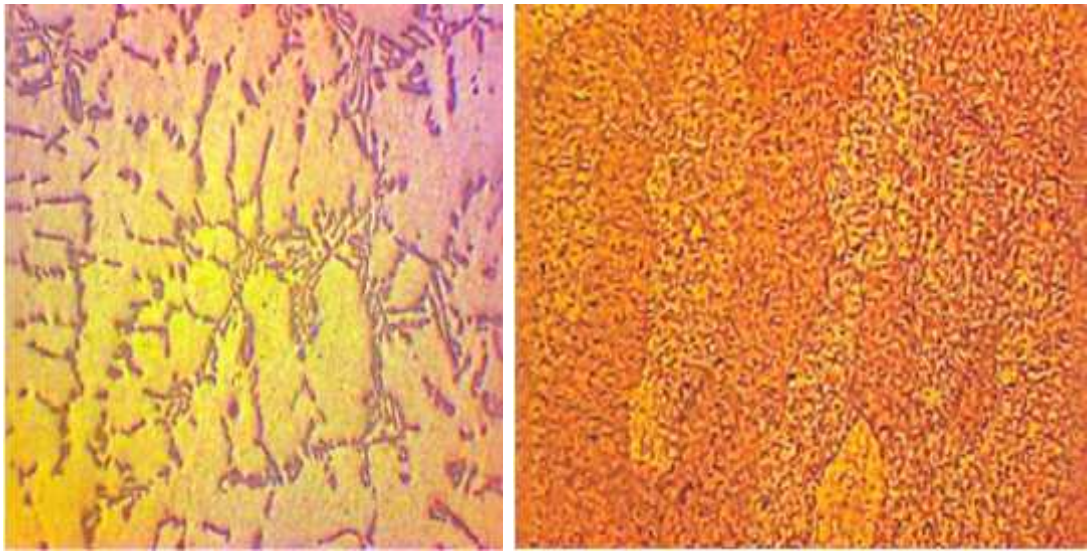
specimen to obtain the final image of the metal structure. Following are the steps involved in the preparation of specimen:

1) Selection of specimen: When investigating the properties of a metal or alloy, it is essential that the specimen should be selected from that area (of the alloy plate or casting) which can be taken as representative of the whole mass.

2) Cutting of the specimen: After selecting a particular area in the whole mass, the specimen may be removed with the help of appropriate cutting tools.



S G Iron



Aluminium Alloy **Copper Alloy**

3) Mounting the specimen: If the specimen is too small to be held in hand forn further processing, it should be mounted on a thermoplastic resin disc or some other low melting point alloy.

4) Obtaining flat specimen surface: It is first necessary to obtain a reasonably flat surface on the specimen. This is achieved by using a fairly coarse file or machining or grinding.

5) Intermediate and Fine Grinding: Intermediate and fine grinding is carried out using emery papers of progressively finer grade.

6) Rough polishing: A very small quantity of diamond powder (particle size about 6 microns) carried in a paste that is oil-soluble is placed on the nylon cloth-covered surface of a rotating polishing wheel. The specimen is pressed against the cloth of the rotating wheel with considerable pressure and is moved around the wheel in the direction opposite to rotation of the wheel to ensure a more uniform action.

7) Fine polishing: The polishing compound used is alumina (Al2O3) powder placed on a cloth covered rotating wheel. Distilled water is used as a lubricant. Fine polishing removes fine scratches and very thin distorted layer remaining from the rough polishing stage.

8) Etching:

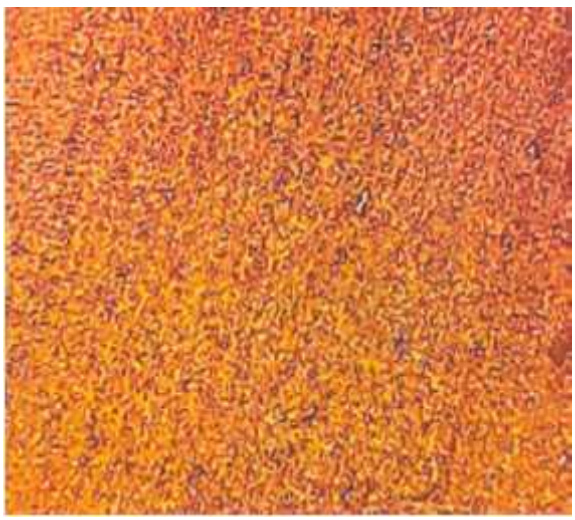
Necessity-Even after fine polishing, the granular structure in a specimen usually cannot be seen under the microscope; because grain boundaries in a metal have a thickness of the order of a few atom diameters at best, and the resolving power of a microscope is much too low to reveal their presence. In order to make the grain boundaries visible, after polishing the metal specimens are usually etched. Etching imparts unlike appearances to the metal constituents and thus makes metal structure apparent under the microscope.

Method- Before etching, the polished specimen is thoroughly washed in running water. Then, the etching is done either by,

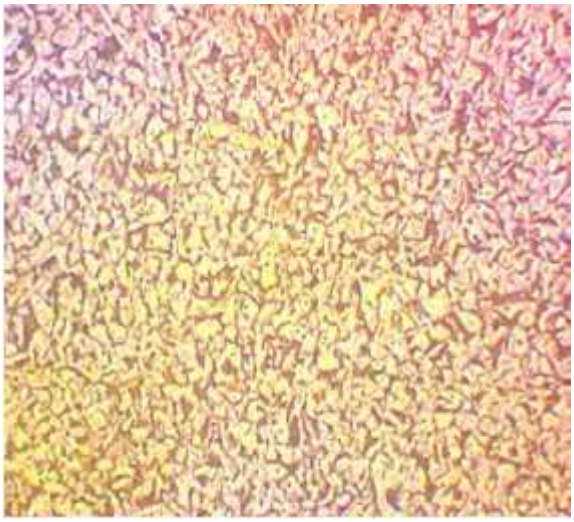
(i) Immersing the polished surface of the specimen in the etching reagent or by

(ii) Rubbing the polished surface gently with a cotton swab wetted with the etching reagent.

After etching, the specimen is again washed thoroughly and dried. Now, the specimen can be studied under the microscope.



Mild Steel



High Speed Steel

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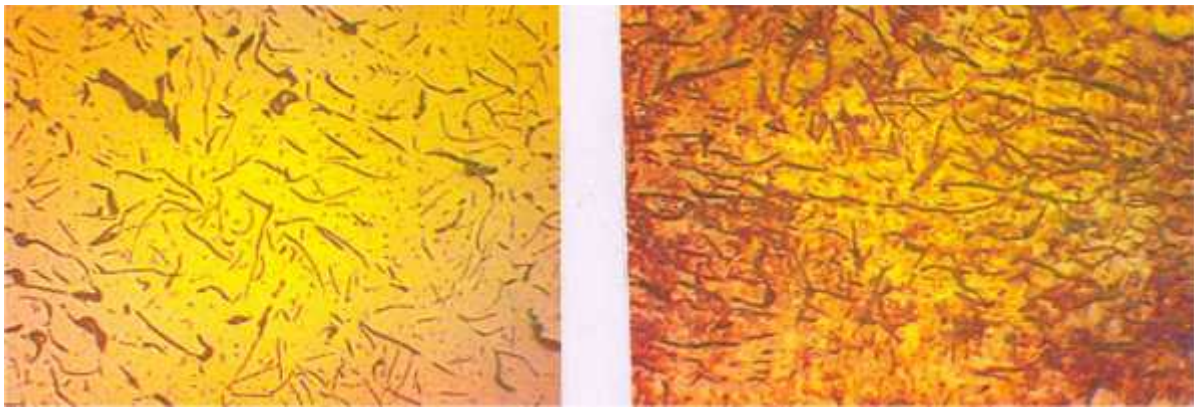
Lab Manual



Grey Cast Iron

EXPERIMENT NO: 6 Study of heat treatment process.
Aim: Study of heat treatment process.

Theory:

HEAT TREATMENT PROCESSES

In general, heat treatment can be defined as an operation, or the combination of operations that involve heating and cooling of a metal in solid phase to obtain certain required properties. The ferrous materials can be heated to above transformation temperature and can be heat – treated to obtain different structure. The different heat treatment processes are based on heating the material to certain temperature and employing different cooling rates. In this process, heating temperature and rate of cooling adopted plays an important role.

The different processes are:

- Annealing
- Stress-relief annealing.
- Process annealing.
- Spheroidising.
- Full annealing.
- Normalizing
- Hardening
- Tempering

Annealing:

Annealing primarily is the process of *heating* a metal which is in a metastable or distorted structural state, to a temperature which will remove the instability or distortion and then *cooling* it to the room temperature so that the structure is stable and/or *strain free*.

Purpose of Annealing:

1. Removal of residual stress.

2. Refining and homogenizing the structure and to give a coarse pearlite structure.

3. Improving machinability.

4. Improving cold working characteristics for facilitating further cold work.

5. Producing desired microstructure.

6. Removing residual stresses.

7. Improving mechanical, physical, electrical and magnetic properties.

8. Reducing hardness.

Normalizing:

This process involves heating the metal above the transformation temperature up to 900º C and cooling from that temperature adopting the required rate of cooling.

This process involves:

- Heating the metal to around 900º C so that the metal transforms completely into austenite.
- Holding at that temperature for some times (3minutes / mm of thickness)
- Cooling at a rate of 80º C to 90º C per hour up to 700ºC
- Then air – cooled from 700º C to room temperature.

Purpose of Normalizing:

- Refining the grain structure and giving a fine pearlite structure.
- Producing a uniform structure.
- Achieving the required strength and ductility in a steel that is too soft and ductile for machining.
- Improving structures in welds.
- In general, improving engineering properties of steels.

Hardening: (By Quenching)

Hardening is performed on metals to obtain desired hardness and structure. It involves:

- Heating the metal above transformation temperature, around 900ºC.
- Holding at that temperature for 15 to 30 minutes per 25mm of cross-section.
- Quenching it immediately in a suitable cold medium (brine solution,water, oil etc.)

Hardness obtained will depend upon the Composition of the material, nature and properties of quenching medium and quenching temperature.

Properties obtained by hardening are:

- Desired hardness can be obtained.
- Strength of material is increased.
- Wear resistance is increased.

Tempering:
Hardening of metal produces Martensite structure with some retained austenite. The Martensite structure makes the metal very hard and brittle. The retained austenite is unstable and it will change with time. This transformation of retained austenite even at room temperature leads to distortion of metal. Due to these factors the hardened metal cannot be used as it is. Hence tempering is carried out on the metals.

Tempering treatment involves:
Heating the metal just above Martensite structure temperature (50 O C), Holding it at that temperature for some time and then cooling either rapidly or slowly. The purpose of tempering is to remove brittleness and improve ductility in the material.
The Properties obtained after Tempering are:

- Improvement in ductility and toughness.
- Slight reduction in hardness.
- Increase in tensile strength.
- Reduction in internal stress.

EXPERIMENT NO: 7 Study of non-destructive techniques, such as dye penetration (DP) Test, ultrasonic or eddy-current test.
Aim: Study of non-destructive techniques, such as dye penetration (DP) Test, ultrasonic or eddy-current test.

Theory: Introduction
Up to this point we have learnt various testing methods that somehow destruct the test specimens. These were, tensile testing, hardness testing, etc. In certain applications, the evaluation of engineering materials or structures without impairing their properties is very important, such as the quality control of the products, failure analysis or prevention of the engineered systems in service.
This kind of evaluations can be carried out with Non destructive test (NDT) methods. It is possible to inspect and/or measure the materials or structures without destroying their surface texture, product integrity and future usefulness.
The field of NDT is a very broad, interdisciplinary field that plays a critical role in inspecting that structural component and systems perform their function in a reliable fashion. Certain standards has been also implemented to assure the reliability of the NDT tests and prevent certain errors due to either the fault in the equipment used, the miss-application of the methods or the skill and the knowledge of the inspectors.
Successful NDT tests allow locating and characterizing material conditions and flaws that might otherwise cause planes to crash, reactors to fail, trains to derail, pipelines to burst, and variety of less visible, but equally troubling events. However, these techniques generally require considerable operator skill and interpreting test results accurately may be difficult because the results can be subjective.
These methods can be performed on metals, plastics, ceramics, composites, cermets, and coatings in order to detect cracks, internal voids, surface cavities, delamination, incomplete defective welds and any type of flaw that could lead to premature failure.
Commonly used NDT test methods can be seen in table 1.These are universal NDT methods; however, very special tests have been developed for specific applications.
Table 1 Commonly used NDT techniques

Technique	Capabilities	Limitations
Visual Inspection	Macroscopic surface flaws	Small flaws are difficult to detect, no subsurface flaws.

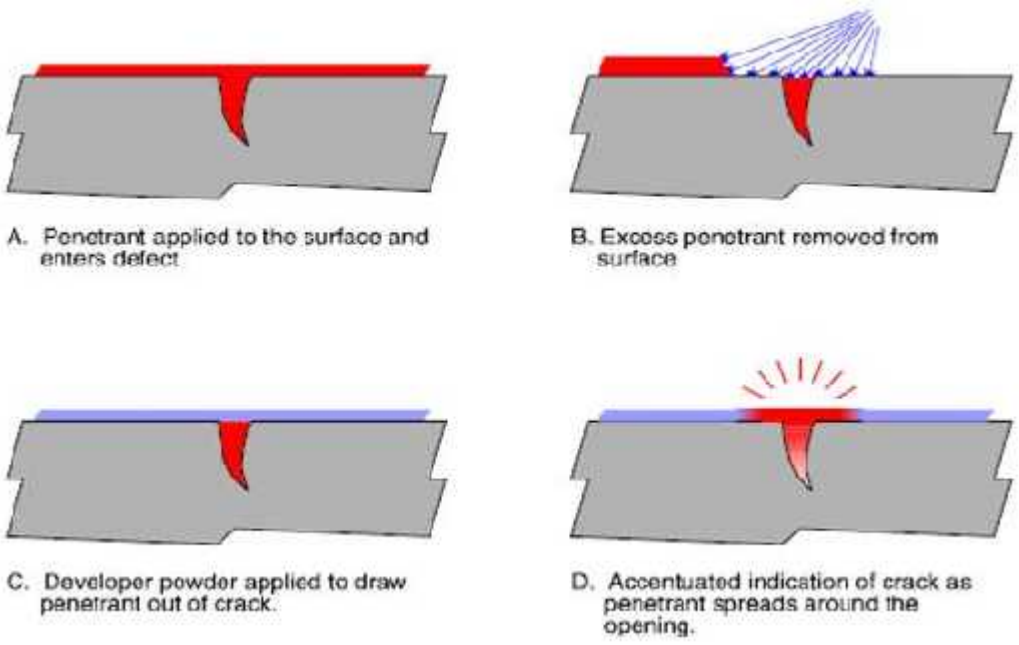
Microscopy	Small surface flaws	Not applicable to larger structures; no subsurface flaws
Radiography	Subsurface flaws	Smallest defect detectable is 2% of the thickness; radiation protection. No subsurface flaws not for porous materials
Dye penetrate	Surface flaws	No subsurface flaws not for porous materials
Ultrasonic	Subsurface flaws	Material must be good conductor of sound
Eddy Current	Surface and near surface flaws	Difficult to interpret in some applications; only for metals.
Acoustic emission	Can analyze entire structure	Difficult to interpret, expensive equipments
Magnetic Particle	Surface / near surface and layer flaws	Limited subsurface capability, only for ferromagnetic materials.

Visual inspection:
VI is particularly effective detecting macroscopic flaws, such as poor welds. Many welding flaws are macroscopic: crater cracking, undercutting, slag inclusion, incomplete penetration welds, and the like. Likewise, VI is also suitable for detecting flaws in composite structures and piping of all types. Essentially, visual inspection should be performed the way that one would inspect a new car prior to delivery, etc. Bad welds or joints, missing fasteners or components, poor fits, wrong dimensions, improper surface finish, delaminations in coatings, large cracks, cavities, dents, inadequate size, wrong parts, lack of code approval stamps and similar proofs of testing.

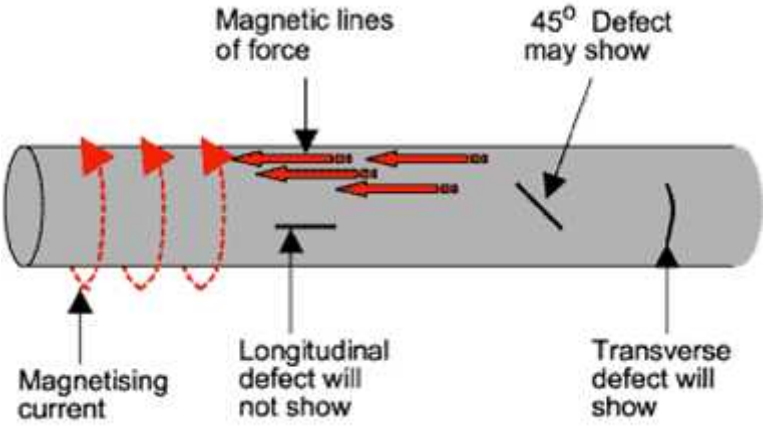
Radiography:
Radiography has an advantage over some of the other processes in that the radiography provides a permanent reference for the internal soundness of the object that is radiographed. The x-ray emitted from a source has an ability to penetrate metals as a function of the accelerating voltage in the x-ray emitting tube. If a void present in the object being radiographed, more x-rays will pass in that area and the film under the part in turn will have more exposure than in the non-void areas. The sensitivity of x-rays is nominally 2% of the materials thickness. Thus for a piece of steel with a 25mm thickness, the smallest void that could be detected would be 0.5mm in dimension. For this reason, parts are often radiographed in different planes. A thin crack does not show up unless the x-rays ran parallel to the plane 0 the crack. Gamma radiography is identical to x-ray radiography in function. The difference is the source of the penetrating electromagnetic radiation which is a radioactive material such m Co 60. However this method is less popular because of the hazards of handling radioactive materials.

Liquid (Dye) penetrate method:
Liquid penetrate inspection (LPI) is one of the most widely used non-destructive evaluation (NDE) methods. Its popularity can be attributed to two main factors, which are its relative ease of use and its flexibility. The technique is based on the ability of a liquid to be drawn into a "clean" surface breaking flaw by capillary action.

This method is an inexpensive and convenient technique for surface defect inspection. The limitations of the liquid penetrate technique include the inability to inspect subsurface flaws and a loss of resolution on porous materials. Liquid penetrate testing is largely used on nonmagnetic materials for which magnetic particle inspection is not possible.
Materials that are commonly inspected using LPI include the following; metals (aluminum, copper, steel, titanium, etc.), glass, many ceramic materials, rubber, plastics. Liquid penetrate inspection is used to inspect of flaws that break the surface of the sample. Some of these flaws are listed below; fatigue cracks, quench cracks grinding cracks, overload and impact fractures, porosity, laps seams, pin holes in welds, lack of fusion or braising along the edge of the bond line.



Magnetic particles:
Magnetic particle inspection is one of the simple, fast and traditional non-destructive testing methods widely used because of its convenience and low cost. This method uses magnetic fields and small magnetic particles, such as iron filings to detect flaws in components. The only requirement from an inspect ability standpoint is that the component being inspected must be made of a ferromagnetic material such iron, nickel, cobalt, or some of their alloys, since these materials are materials that can be magnetized to a level that will allow the inspection to be effective. On the other hand, an enormous volume of structural steels used in engineering is magnetic. In its simplest application, an electromagnet yoke is placed on the surface of the part to be examined, a kerosene-iron filling suspension is poured on the surface and the electromagnet is energized. If there is a discontinuity such as a crack or a flaw on the surface of the part, magnetic flux will be broken and a new south and north pole will form at each edge of the discontinuity. Then just like if iron particles are scattered on a cracked magnet, the particles will be attracted to and cluster at the pole ends of the magnet, the iron particles will also be attracted at the edges of the crack behaving poles of the magnet. This cluster of particles is much easier to see than the actual crack and this is the basis for magnetic particle inspection. For the best sensitivity, the lines of magnetic force should be perpendicular to the defect.



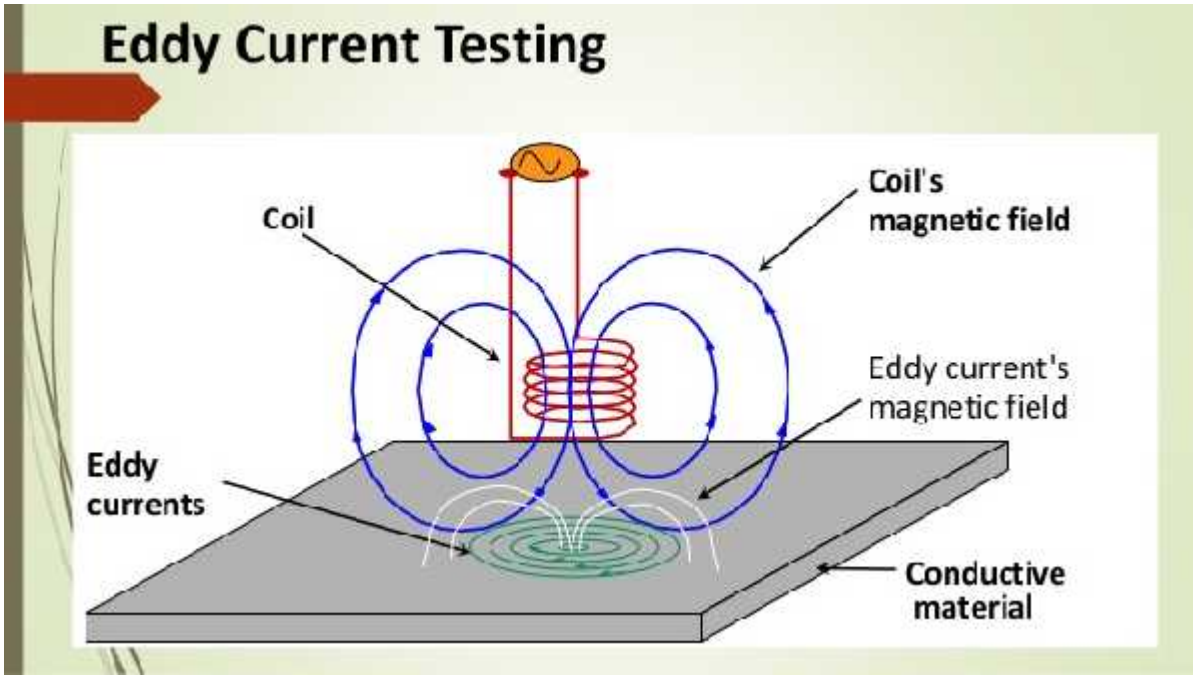
Eddy current testing:

Eddy currents are created through a process called electromagnetic induction. When alternating current is applied to the conductor, such as copper wire, a magnetic field develops in and around the conductor. This magnetic field expands as the alternating current rises to maximum and collapses as the current is reduced to zero. If another electrical conductor is brought into the close proximity to this changing magnetic field, current will be induced in this second conductor. These currents are influenced by the nature of the material such as voids, cracks, changes in grain size, as well as physical distance between coil and material. These currents form an impedance on a second coil which is used to as a sensor.

In practice a probe is placed on the surface of the part to be inspected, and electronic equipment monitors the eddy current in the work piece through the same probe. The sensing circuit is a part of the sending coil.

Eddy currents can be used for crack detection, material thickness measurements, coating thickness measurements, conductivity measurements for material identification, heat damage detection, case depth determination, heat treatment monitoring. Some of the advantages of eddy current inspection include; sensitivity to small cracks and other defects, ability to detect surface and near surface defects, immediate results, portable equipment, suitability for many different applications, minimum part preparation, no necessity to contact the part under inspection, ability to inspect complex shapes and sizes of conductive materials.

Some limitation of eddy current inspection; applicability just on conductive materials, necessity for an accessible surface to the probe, skillful and trained personal, possible interference of surface finish and roughness, necessity for reference standards for setup, limited depth of penetration, inability to detect of the flaws lying parallel to the probe coil winding and probe scan direction.



Ultrasonic Inspection:

Ultrasonic Testing (UT) uses a high frequency sound energy to conduct examinations and make measurements. Ultrasonic inspection can be used for flaw detection evaluation, dimensional measurements, material characterization, and more. A typical UT inspection system consists of several functional units, such as the pulser/receiver, transducer, and display devices. A pulser/receiver is an electronic device that can produce high voltage electrical pulse. Driven by the pulser, the transducer of various types and shapes generates high frequency ultrasonic energy operating based on the piezoelectricity technology with using quartz, lithium sulfate, or various ceramics. Most inspections are carried out in the frequency rang of 1 to 25MHz. Couplants are used to transmit the ultrasonic waves from the transducer to the test piece; typical couplants are water, oil, glycerin and grease.

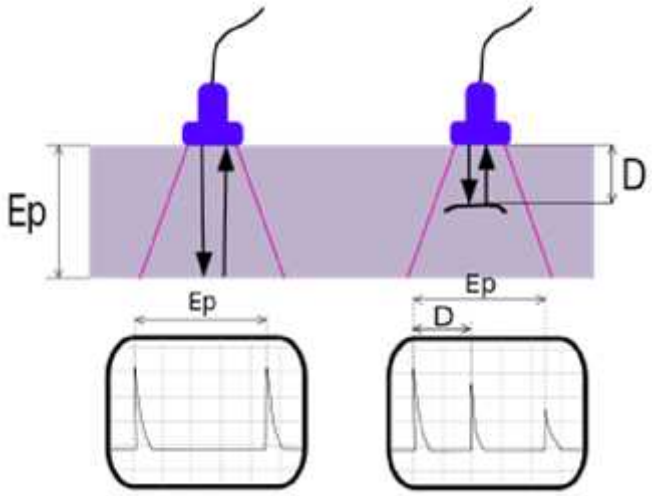
The sound energy is introduced and propagates through the materials in the form of waves and reflected from the opposing surface. An internal defect such as crack or void interrupts the waves' propagation and reflects back a portion of the ultrasonic wave. The amplitude of the energy and the time required for return indicate the presence and location of any flaws in the work-piece.

The ultrasonic inspection method has high penetrating power and sensitivity. It can be used from various directions to inspect flaws in large parts, such as rail road wheels pressure vessels and die blocks. This method requires experienced personnel to properly conduct the inspection and to correctly interpret the results.

As a very useful and versatile NDT method, ultrasonic inspection method has the following advantages; sensitivity to both surface and subsurface discontinuities, superior depth of penetration for flaw detection or measurement, ability to single sided access for pulse-echo technique, high accuracy in determining reflector position and estimating size and shape, minimal part preparation, instantaneous results with electronic equipment, detailed imaging with automated systems, possibility for other uses such as thickness measurements.

Its limitations; necessity for an accessible surface to transmit ultrasound, extensive skill and training, requirement for a coupling medium to promote transfer of sound energy into test specimen, limits for roughness, shape irregularity, smallness, thickness or not homogeneity, difficulty to inspect of coarse grained materials due to low sound transmission and high signal noise, necessity for the linear defects to be oriented parallel to the sound beam,

necessity for reference standards for both equipment calibration, and characterization of flaws.

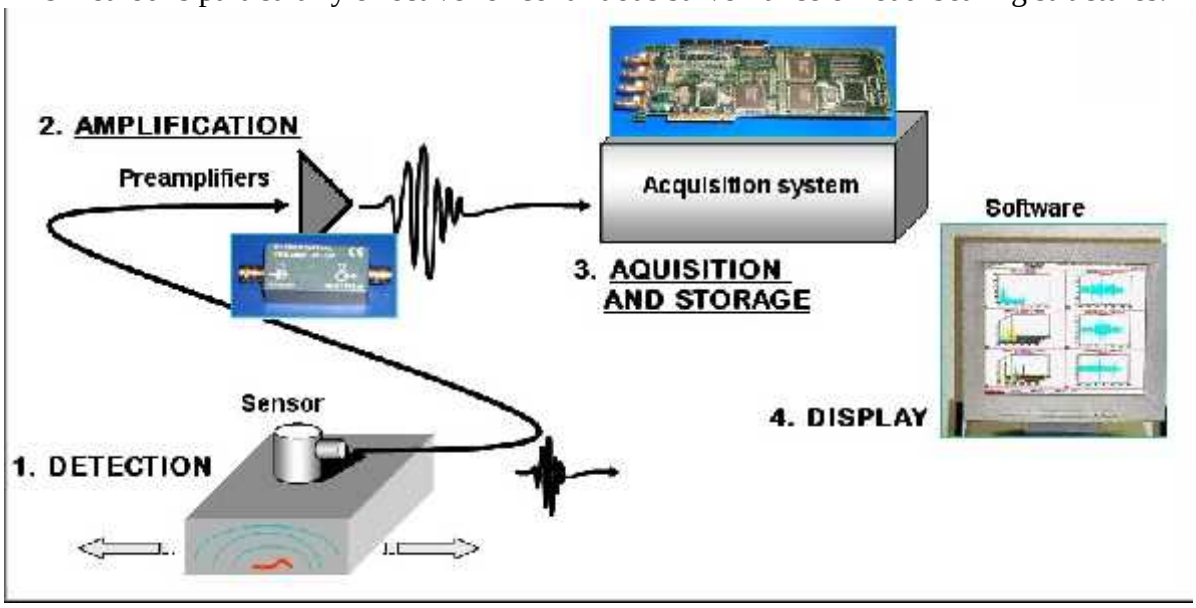


Acoustic Method:

There are two different kind of acoustic methods: (a) acoustic emission; (b) acoustic impact technique.

Acoustic emission:

This technique is typically performed by elastically stressing the part or structure, for example, bending a beam, applying torque to a shaft, or pressurizing a vessel and monitoring the acoustic responses emitted from the material. During the structural changes the material such as plastic deformation, crack initiation, and propagation, phase transformation, abrupt reorientation of grain boundaries, bubble formation during boiling in cavitation, friction and wear of sliding interfaces, are the source of acoustic signals. Acoustic emissions are detected with sensors consisting of piezoelectric ceramic elements. This method is particularly effective for continuous surveillance of load-bearing structures.



Acoustic impact technique:

This technique consists of tapping the surface of an object and listening to and analyzing the signals to detect discontinuities and flaws. The principle is basically the same as when one taps walls, desktops or countertops in various locations with a finger or a hammer and listens to the sound emitted. Vitrified grinding wheels are tested in a similar manner to detect cracks in the wheel that may not be visible to the naked eye. This technique is easy to

perform and can be instrumented and automated. However, the results depend on the geometry and mass of the part so a reference standard is necessary for identifying flaws.

Procedure

Liquid penetrate method:

In this method the surfaces to be inspected should be free from any coatings, paint, grease, dirt, dust, etc.; therefore, should be cleaned with an appropriate way. Special care should be taken not to give additional damage to the surface to be inspected during the cleaning process. Otherwise, the original nature of surface could be disturbed and the results could be erroneous with the additional interferences of the surface features formed during the cleaning process.

Surface cleaning can be performed with alcohol. Special chemicals like cleaner remover can also be applied if needed. In the experiment, only cleaner-remover will be sufficient. Subsequent to surface cleaning, the surface is let to dry for 2 minutes. Commercially available cans of liquid penetrate dyes with different colors are used to reveal the surface defects.

***Steps used in the experiment**:*

1. Clean the surface with alcohol and let surface dry for 5 min.
2. Apply the liquid penetrate spray (red can) to the surface and brush for further penetration. Then, wait for 20 min.
3. Wipe the surface with a clean textile and subsequently apply remover spray (blue can) to remove excess residues on the surface and wait for a few min.
4. Apply the developer spray (yellow can) at a distance of about 30cm from the surface. The developer will absorb the penetrate that infiltrated to the surface features such as cracks, splits, etc., and then reacted with it to form a geometric shape which is the negative of the geometry of the surface features from which the penetrate is sucked.
5. The polymerized material may be collected on a sticky paper for future evaluation and related documentation, if needed.

Magnetic particle:

In this experiment, commercially available magnetic powder manufactured for NDT inspection will be used. A strong U shape magnet will be used to provide the necessary magnetic field at the inspected area.

The following steps are applied during the experiment;

1. The surface of the specimen will be roughly cleaned wiping with a piece of textile.
2. The fluorescent magnetic spray will be applied on the surface being inspected.
3. Magnetic field will be applied with a strong magnet to the location of interest.
4. The spots where the fluorescent magnetic particles accumulated will be inspected under UV light.

Eddy current inspection:

For this experiment, Magnefest ED-51 0 type unit will be used. A pencil type prop will be used for the inspections. The inspection is performed with 2 MHz frequency and at the related calibration settings. The test blocks were previously prepared for this experiment. Any coatings or paints on the surface of inspected specimens should be treated with special procedures.

The following steps should be applied during the experiment:

l. Inspection area should be clean, smooth, free from any irregular or uneven paint, dirt, grease, etc.
2. There shouldn't be any visible damage or discontinuity.

3. During the inspection procedure the probe will be positioned near the inspection area, on the compensation point and lift off and zero will be adjusted if necessary.
4. The inspection will be carried out by using probe scans. The probe tip will be always at a right angle the inspection surface.
5. Any indication with indicator deflection to the right should be evaluated. All evaluated indications should be measured.
6. After this procedure, all evaluated indications with indicator deflections, will be classified as cracks and be recorded.

Ultrasonic inspection:
For this experiment, USM-2 type ultrasonic unit will be used. The props used supports to work at frequency of 5 MHz. Echo techniques will be employed to find the cracks. Instrument will be tuned to a frequency of 5 MHz. An appropriate couplant used should not cause corrosion or other damage. During the inspection the calibration will be done on the reference standard, if needed. Two different test blocks will be employed in this test, sufficient amount of couplant will be applied to the transducer scan areas on the forward and after sides of the support fitting. The display will be monitored for crack indications. A crack signal will be similar to the following:

The following steps should be applied during the experiment:
1. The couplant should be applied on the inspected area.
2. For the circular test specimen, the prop will be placed in the corresponding space in the supporting fitting tool. Enough couplant should be used between the probe and tool.
3. For the flat specimen, no tool is needed, couplant only applied between the inspected surface and the probe.
4. Special attention should be paid on the location where possible cracks exist.
5. A discontinuity like a crack produces a peak on the screen.
6. Attention should also be given to the movement of the possible peak caused by the cracks on the specimen.

UNIVERSITY OF ENGINEERING & MANAGEMENT, JAIPUR

Lab Manual

Title of Course: Electrical & Electronic Measurement Lab
Course Code: CE795B
L-T-P scheme: 0-0-3 **Course Credit: 2**

Objectives:
1. To introduce the student fundamentals of Electronics Instruments and Measurement
2. To understand how measuring instruments work for measurement of electrical and non electrical quantity.
3. Providing practical ideas and an in-depth understanding of Measurement procedures.

Learning Outcomes: The students will have a detailed knowledge of the concepts of different measuring methods and the devices that has to be used for the purpose. Upon the completion of Operating Systems practical course, the student will be able to:

- **Understand** necessity of measuring devices and also proper selection of the devices
- **Use** proper instruments for measuring electrical and non electrical quantities**.**
- **Understand** effects of the internal impedances of meteres while measuring.
- **Analyze** General features of analog meteres
- **Learn** the application of ac and dc potentiometer to measure unknown emf
- **Understand** the fundamental concepts of CRO and it's use to measure electrical parameters

Course Contents:
Exercises that must be done in this course are listed below:
Exercise No. 1: Measure a resistance using Kelvin's Double Bridge
Exercise No. 2: Measure unknown capacitance using Schering Bridge
Exercise No. 3: Measure self inductance using Anderson's Bridge.
Exercise No. 4: Measure unknown value of capacitance using De Sauty Bridge
Exercise No. 5: Measure Unknown frequency using Wein's Bridge
Exercise No. 6: Measure three phase power and power factor
Exercise No. 7: Study the operation of CRO

Text Book:
1. A.K. Sawhney, A course in Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai and sons

Recommended Systems/Apparatus Requirements:
1. Laboratory Kits, Multimeters, CRO, Connecting wires.

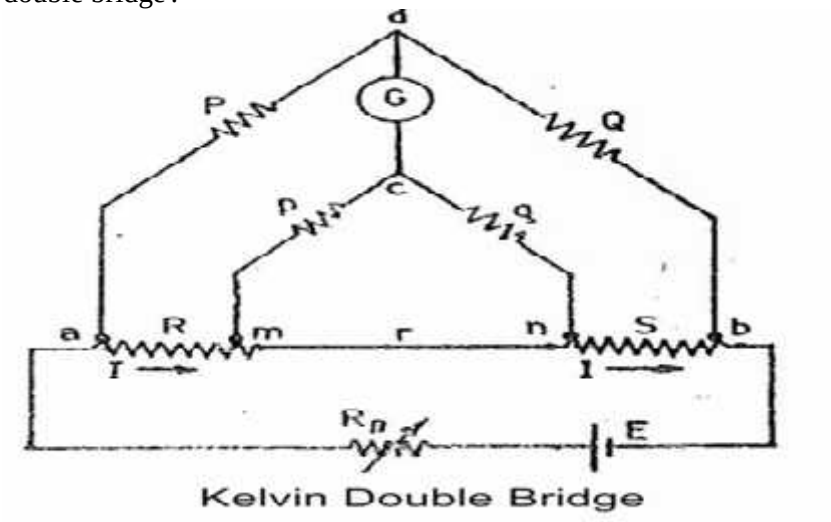
Experiment No: 1

Measure a resistance using Kelvin's Double Bridge

Aim: To measure a low resistance using Kelvin's Double Bridge.

Theory:

Kelvin Double Bridge is nothing but a modification of Wheatstone bridge. It is used for measuring of low resistance to a good precision. It compares two ratio arms P,Q and p,q and hence is called 'double bridge'.



Kelvin Double Bridge

P, Q, p, q are the resistances in the ratio arms. G is a galvanometer of D'Arsonal type, used as a null detector. S is a small standard resistor; R is a resistance under measurement. Usually low resistance consists of four leads. Two of them are called as voltage leads and remaining as current leads. "r" is the resistance of connecting lead between R and S.

Under balanced conditions,

$$E_{ab} = E_{amd}$$

$$E_{ac} = I\left[R + S + \frac{(p+q)r}{p+q+r}\right]$$

$$By\ equating\ E_{ab} = E_{amd}\ we\ get, R = \frac{P}{Q}S + \frac{qr}{p+q+r}\left[\frac{P}{Q} - \frac{p}{q}\right]$$

From the above equation, it is clear that the resis tance of connecting leads "r" has no effect on the measurement if the two sets of ratio arms have equal ratios ie, P/Q = p/q. The effect of thermo electric Emf can be eliminated by making other measurement with battery terminals reversed and taking the average of the two readings can eliminate the effect of thermo electric Emfs.

Procedure:

Procedure for the measurement of low resistance R using Kelvin Double Bridge

1. Move the Galvanometer switch to increase position. This connects the built-in galvanometer to the circuit. If an external more sensitive galvanometer is available, connect it to the terminals marked "extgalv" and put the galvanometer switch in "EXT" position.
2. Four terminals are provided for connecting unknown resistance of the bridge circuit. They are lab eled by "+C, +P, - C, - P". Here +C and - C constitute the current terminals. If the given unknown resistance is of four leads then connect the two potential leads to +P & -P and current leads to +C & -C with correct current polarity. If the unknown resistance has two terminals then the leads from +C and +P are connected to other terminals of unknown resistance.
3. Now, press the button on the panel and obtain the balance by varying the dials.

5.Find the tolerance of the resistance and tabulate the results.

Observation Table:

The example results are as given in the tabular form below:

S.No	For Kelvin Double Bridge Calculated Value	From Multimeter Theoretical Value(Ω)	% Tolerance

Conclusion:

Experiment No: 2
Measure unknown capacitance using Schering Bridge

Aim: To measure unknown capacitance using Schering Bridge

Theory:
Schering bridge is widely used for capacitance and dissipation factor measurement. It is extensively used in the measurement of capacitance.
At balance

$(r_1 + 1/j\omega C_x)(R_3/(1 + j\omega C_4 R_4)) = 1/j\omega C_2 \times R_3$

$r_1 R_4 - jR_4/\omega C_x = -jR_3/\omega C_2 + R_3 R_4 C_4/C_2$

Equating the real and imaginary parts,

$R_1 = R_3 C_4 / C_2$

$C_x = C_2 (R_4 / R_3)$

Dissipation factor, $D_1 = \text{Tan}\ \delta = \omega C_1 r_1$

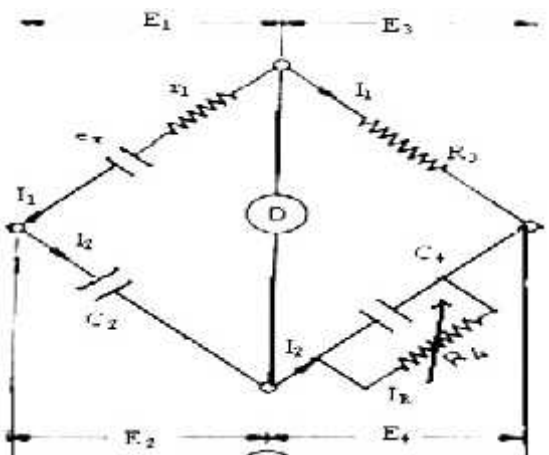
$\omega C_4 R_4$

Formula Used

$C_x = C_2 (R_4 / R_3)$

Where, C_2 Standard capacitor

R_3, R_4 = Non-inductive resistance



Cx - Unknown capacitance
C4 - variable Capacitor
R3, R4 - Non inductive resistance

Procedure:

1. The trainer is switched 'ON' and the unknown capacitance is connected in the terminals Cx
2. Initially the resistance R3 is kept some value and by varying the value of resistance R 4 the balanced condition is obtained
3. The balanced condition is checked
4. All the values are noted down.

Observation Table:

Sr. No.	R3 (1)	C2	R4 (2)	Cx Obs Value	Set Value
Unit	KΩ	μF	Ω	μF	μF
1					
2					

Conclusion:

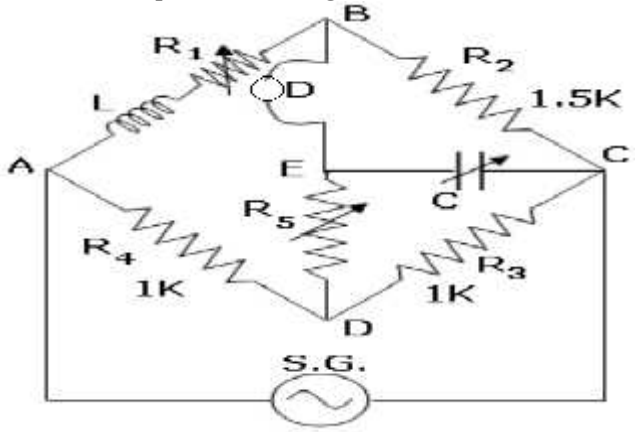
Experiment No: 3

Measure self inductance using Anderson's Bridge.

Aim: To measure self inductance using Anderson's Bridge

Theory:

Anderson's bridge is the most accurate bridge used for the measurement of self – inductance over a wide range of values, from a few micro-Henries to several Henries. In this method the unknown self-inductance is measured in terms of known capacitance and resistances, by comparison. It is a modification of Maxwell's L - C Bridge. In this bridge, double balance is obtained by the variation of resistances only, the value of capacitance being fixed.



Inductance of given coil L $= C[(R_1 + R_3)R_4 + R_2R_4]$ mH

Where C = Capacity of the standard capacitor (μ F)

R_2, R_3, R_4 Known, fixed and non inductive resistances (KΩ)

R_1, R_5 Variable resistances (KΩ)

Procedure:

1. The circuit diagram of the bridge is as shown in the figure.
2. The coil whose self-inductance is to be determined, is connected in the arm AB, in series with a variable non-inductive resistor R1.
3. Arms BC, CD and DA contain fixed and non – inductive resistors R2, R3 and R4 respectively.
4. Another non - inductive resistor R5 is connected in series with a standard capacitor C and this combination is put in parallel with the arm CD.
5. The null detector is connected between B and E.
6. The signal generator is connected between A and C junctions.
7. Select one capacitor and one inductor and connect them in appropriate places using patch chords.
8. A perfect balance is obtained by adjusting R1 and R5 alternatively till the detector D indicate a minimum balance .
9. The values of R1 and R5 are measured with a multi-meter(While measuring the R1 and R5 values, they should be in open circuit) .
10. In the balance condition the self – inductance value of the coil is calculated by using the above formula.

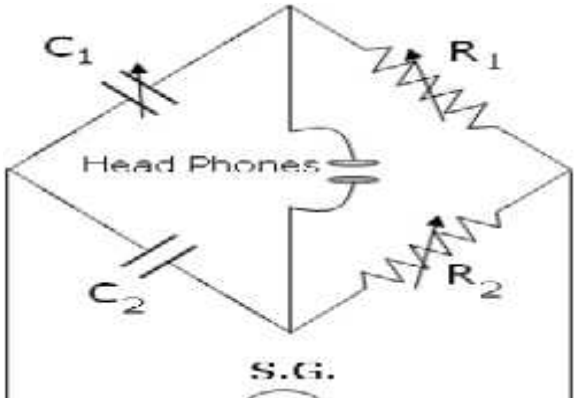
Observation Table:

S.No.	Capacity (C) μF	Resistance (R_1) Ω	Resistance (R_5) Ω	Calculated value (L) $C[(R_1+R_2)R_5+R_2R_1]$ mH	Standard value of L mH

Conclusion:

Experiment No: 4
Measure unknown value of capacitance using De Sauty Bridge
Aim: To measure unknown value of capacitance using De Sauty Bridge

Theory:
The De Sauty's bridge is an A.C Bridge works on the principle of Wheat stone's bridge. This bridge is used to determine the capacity of an unknown capacitor C2 in terms of the capacity of a standard known capacitor C1. Here R1 and R2 are non - inductive resistors. R1, R2, C1 and C2 are connected in a Wheat stone's bridge as shown in the figure. When the bridge is balanced, the ratios of impedances are equal



At balanced condition Capacity of a unknown capacitor

C2 = (R1 / R2) x C1 μF

Procedure:

1. The connections are made as shown in the figure.
2. The resistance R1 and a condenser C1 are in series in one branch of the bridge and a resistance R2 and another capacitor C2 are in series in another branch.
3. The A.C signal generator frequency is adjusted to a fixed value of 1 KHz or below, which is convenient to our ear.
4. A resistance is unplugged in R1 and the resistance R2 is adjusted till the sound in the head - phone is reduced to zero level.
5. The value of R2 is measured with a multi-meter and noted. While measuring the resistances, they should be in open circuit.
6. The above process is repeated for different values of R1 and the values are noted in the table.
7. When the hum in the head – phone is at zero level , then the time constants of the upper and the lower braches of Wheat stone's bridge equal i.e. C1R1= C2R2

Observation Table:

S.No.	Capacity of known condenser C_1 μF	Resistance R_1 Ω	Resistance R_2 Ω	Capacity of unknown condenser $C_2 = \frac{R_1}{R_2} X C_1$ μF	Standard Value of C_2 μF

Conclusion:

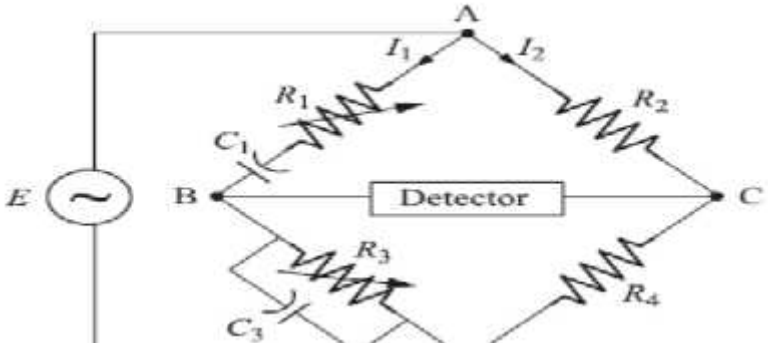
Experiment No: 5

Measure Unknown frequency using Wein's Bridge

Aim: To measure Unknown frequency using Wein's Bridge

Theory:

In this bridge circuit, there is a lead-lag network. Balancing of the bridge is easier because satisfying the phase angle equality condition can be achieved. This bridge can also be used to determine the frequency of the AC input in terms of the component values of the bridge circuit. In this AC Bridge, there is no inductor. Inductive losses because of stray fields cause problems in balancing of the bridge. Owing to the absence of L in the circuit, this can be effectively used for determining the frequency f of the AC input.



At balanced condition the unknown frequency can be given as

$$f= 1/[2\pi\sqrt{(R_1 R_3 C_1 C_3)}]$$

Procedure:

1. Connect mains cord to the Trainer.
2. Connect terminal 1 to 4(for evaluating unknown capacitance Cx1).
3. Rotate variable resistance R1 towards anti clockwise direction.
4. Select Frequency Selector f or any desired range of frequency.
5. Vary resistance R1 towards clockwise direction slowly.
6. Keep varying R1 until null condition is achieved
7. Now remove the patch cord between terminal 1 & 4 and record the value of R1 in the observation table using multimeter

Observation Table:

S No.	R1	R2	C1	C2	I
1					
2					
3					
4					
5					

Conclusion:

Experiment No: 6
Measure three phase power and power factor
Aim: To Measure three phase power and power factor
Theory:
Power consumed by a 3-phase balanced or unbalanced load (star connected) can be measured by using 2-wattmeters properly connected in the circuit.The current coil of the wattmeter are connected in series with the load in any two line. Where as the pressure coils are connected between these two lines and the third line. The phasor diagram of this circuit assuming balanced lagging load has been shown in the figure. Under running conditions the power consumed by the three phase system is the sum o the two individual wattmeters.

Mathematically, the total power consumed,

$$W1 + W2 = \sqrt{3}\times V\ \{\cos(30 - \emptyset) + \cos(30 + \emptyset)\}$$

Where,

Power consumed by wattmeter1=$\sqrt{3}\times V\ \{\cos(30 - \emptyset)\}$

Power consumed by wattmeter 2=$\sqrt{3}\times V\ \{\cos(30 + \emptyset)\}$

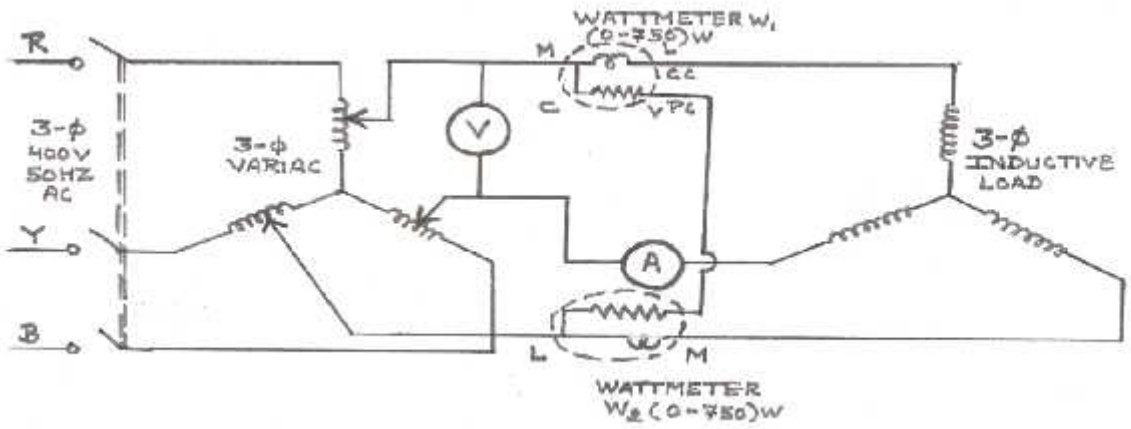
When the load power factor is less then 0.5 then wattmeter 2 will show the correct deflection and first wattmeter will show the reverse deflection. In the first wattmeter the current coil or voltage coil connection is reversed. Thus the wattmeter pointer direction is corrected. The net power is obtained

Power angle is given by

$$\emptyset = tan^{-1}\sqrt{3}\times\frac{(W1-W2)}{(W1+W2)}$$

Then the power factor of the load can be calculated as:

$$cos\emptyset = cos[tan^{-1}\sqrt{3}\times\frac{(W_1-W_2)}{(W_1+W_2)}]$$



Procedure:

1. Connect the circuit as shown in the diagram.
2. Vary the inductive load.
3. Note down the reading carefully.
4. If one wattmeter reads negative or gives reverse reading, the reading of wattmeter is taken by reversing the current coil terminal.

Observation Table:

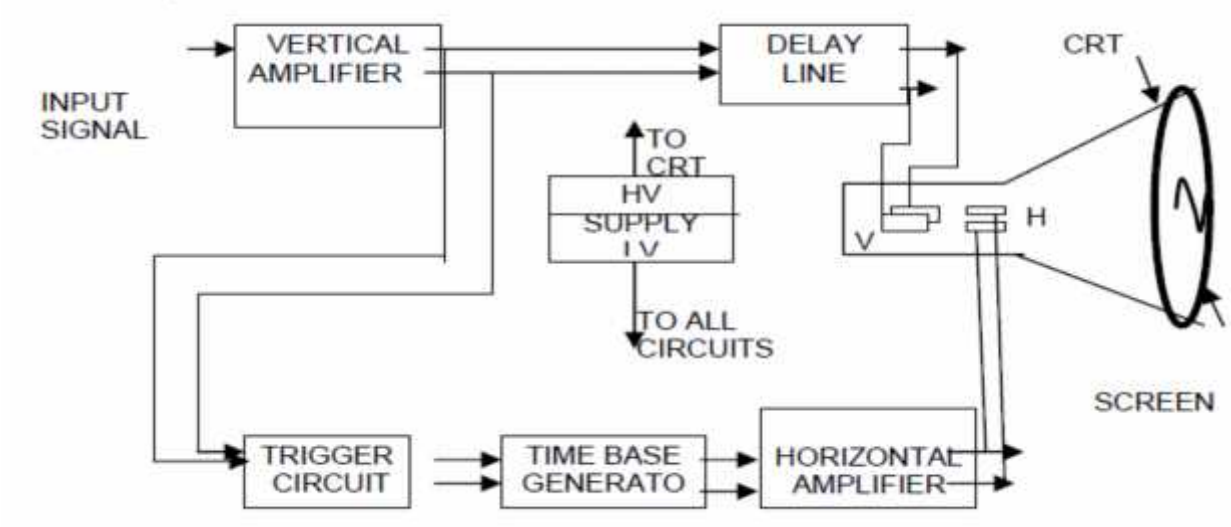
Sl. No.	**Voltage VL (volts)**	**Current IL (amp)**	**Power W1 (Watts)**	**Power W2 (Watts)**	**Total Power P=W1+W2**	**Power Factor=cosØ**

Conclusion:

Experiment No: 7
Study the operation of CRO
Aim: To Study of CRO & Measurement of frequency using Lissajous Patterns.

Theory:
The cathode ray oscilloscope is the most versatile measuring instrument available. We can measure following parameters using the CRO:
1. AC or DC voltage.
2. Time (t=1/f).
3. Phase relationship
4. Waveform calculation: Rise time; fall time; on time; off-time Distortion, etc.
We can also measure non-electrical physical quantities like pressure, strain, temperature, acceleration, etc., by converting into electrical quantities using a transducer.

Major blocks:
1. Cathode ray tube (CRT)
2. Vertical amplifier
3. Horizontal amplifier
4. Sweep generator
5. Trigger circuit
6. Associated power supply.



BLOCK DIAGRAM OF CRO

1. **The cathode ray tube** is the heart of CRO. The CRT is enclosed in an evacuated glass envelope to permit the electron beam to traverse in the tube easily. The main functional units of CRO are as follows.
Electron gun assembly, Deflection plate unit, Screen.

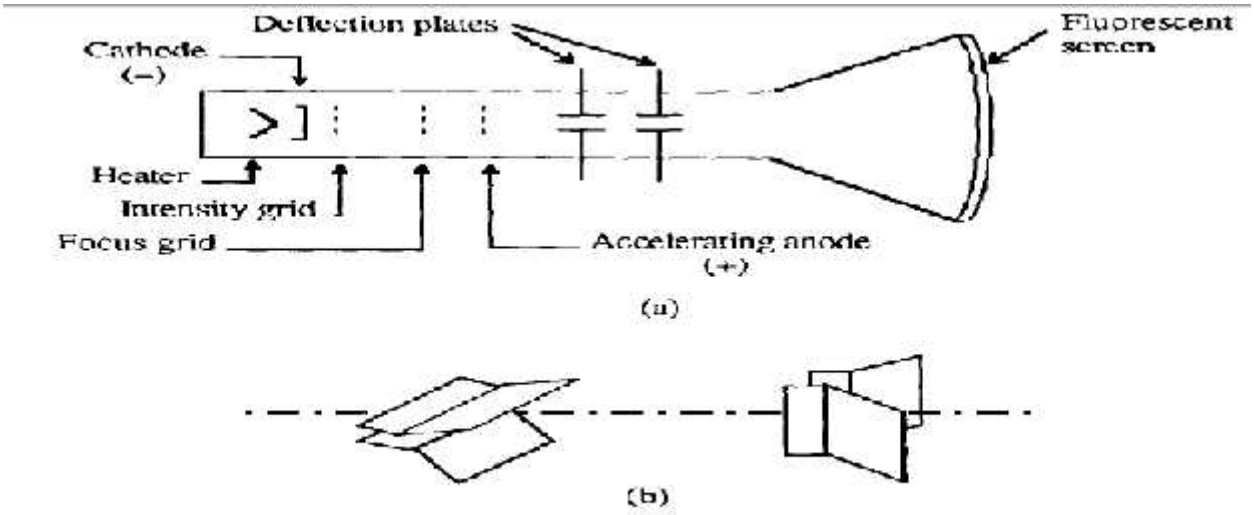


Figure 1. Cathode-ray tube: (a) schematic, (b) detail of the deflection plates.

2. **Vertical Amplifier** is the main factor in determining the bandwidth and sensitivity of an oscilloscope. Vertical sensitivity is a measure of how much the electron beam will be deflected for a specified input signal. On the front panel of the oscilloscope, one can see a knob attached to a rotary switch labeled volts/division. The rotary switch is electrically connected to the input attenuation network. The setting of the rotary switch indicates what amplitude signal is required to deflect the beam vertically by one division.

3. **Horizontal amplifier** under normal mode of operation, the horizontal amplifier will amplify the sweep generator input. When the CRO is being used in the X-Y mode, the horizontal amplifier will amplify the signal applied to the horizontal input terminal. Although the vertical amplifier mush be able to faithfully reproduce low-amplitude and high frequency signal with fast rise time, the horizontal amplifier is only required to provide a faithful reproduction of the sweep signal which has a relatively high amplitude and slow rise time.

4. Sweep generator and Trigger circuit These two units form the Signal Synchronization unit of the CRO.

5. **Associated Power Supply:** The input signal may come from an external source when the trigger selector switch is set to EXT or from low amplitude AC voltage at line frequency when the switch is set to LINE or from the vertical amplifier when the switch is set to INT. When set for INT (internal triggering), the trigger circuit receives its inputs from the vertical amplifier.

Procedure:

1.1 Measurement of Voltage Using CRO :

A voltage can be measured by noting the Y deflection produced by the voltage; using this deflection in conjunction with the Y-gain setting, the voltage can be calculated as follows :

V = (no. of boxes in cm.) x (selected Volts/cm scale)

1.2 Measurement of Current and Resistance Using a CRO :

Using the general method, a correctly calibrated CRO can be used in conjunction with a known value of resistance R to determine the current I flowing through the resistor.

1.3 Measurement of Frequency Using a CRO :

A simple method of determining the frequency of a signal is to estimate its periodic time from the trace on the screen of a CRT. However this method has limited accuracy, and

the observed signal, one has to measure the period, i.e. the time taken for 1 complete cycle, using the calibrated sweep scale. The period could be calculated by

T = (no. of squares in cm) x (selected Time/cm scale)

Once the period T is known, the frequency is given by

f (Hz)= 1/T(sec)

1.4. Measurement of Phase:

The calibrated time scales can be used to calculate the phase shift between two sinusoidal signals of the same frequency. If a dual trace or beam CRO is available to display the two signals simultaneously (one of the signals is used for synchronization), both of the signals will appear in proper time perspective and the amount of time difference between the waveforms can be measured. This, in turn can be utilized to calculate the phase angle∀, between the two signals.

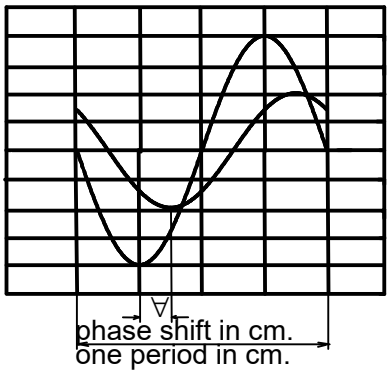


Figure 1:- PHASE SHIFT BETWEEN TWO SIGNALS

Referring to figure.1, the phase shift can be calculated by the formula;

$$-X\frac{\text{Phase shift in cm.}}{\text{One period in cm.}} \text{ x } 360\lceil$$

Note that the calculation does not involve the actual calibrated time base setting. In fact, the observed waveforms can be varied using the horizontal amplifier venire adjustment to obtain as many boxes for one full scale as desired. Another method for fast calculation is to multiply the scale factor by the phase difference (in cm) where the scale factor is degrees per box or degrees per cm.

1.5 Use of Lissajous Patterns for Frequency Measurements:

If a well calibrated CRO timebase is not available, a signal generator can be used to measure the frequency of an unknown sinusoidal signal. It is connected to the vertical channel (or horizontal) and the calibrated signal source is fed to the horizontal channel (or vertical).The frequency of the signal generator is adjusted so that a steady Lissajous pattern is obtained. The Lissajous pattern can be very involved to analyze. However, for the frequency

measurement, all that is needed is the number of tangencies (points at the edge of arcs) along the vertical and horizontal lines.

The frequency relationship between the horizontal and vertical inputs is given by;

$$\frac{f_h}{f_v} X \frac{\text{No. of tangencies (vertical)}}{\text{No. of tangencies (horizontal)}}$$

from which f_V , the unknown frequency can be calculated.

Conclusion:

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Course Description

Title of Course: Seminar on Industrial Training **Course Code: CE781**
L-T –P Scheme: 0-0-3 **Course Credits: 2**

Course Description & Objectives:

1. **Understand** the history of medical research and bioethics related to the HeLa cells. Understand the diverse social and economic, racial and gender contexts within which Henrietta Lacks lived and died. Understand the themes of this seminar. Appreciate the legacy and implications of these medical, ethical and social understandings on today's society.

2. **Identify**, understand and discuss current, real-world issues.

3. **Distinguish** and **integrate** differing forms of knowledge and academic disciplinary approaches (e.g., humanities and sciences) with that of the student's own academic discipline (e.g., in agriculture, architecture, art, business, economics, education, engineering, natural resources, etc.). And apply a **multidisciplinary strategy** to address current, real-world **issues**.

4. Improve oral and written **communication** skills.

5. Explore an appreciation of the **self** in relation to its larger diverse social and academic contexts.

6. Apply principles of **ethics** and **respect** in interaction with others.

Course Outcomes:

After the completion of this course, the student should be able to:

1. **Learn and integrate.** ***Through independent learning and collaborative study, attain, use, and develop knowledge*** *in the arts, humanities, sciences, and social sciences, with disciplinary specialization and the ability to integrate information across disciplines.*

2. *Use multiple thinking strategies to* ***examine real-world issues, explore creative avenues of expression, solve problems, and make consequential decisions***

3. **Learn and integrate.** Communicate**.** *Acquire, articulate, create and convey intended meaning using* ***verbal*** *and* ***non-verbal method of communication*** *that demonstrates respect and understanding in a complex society.*

4. *Use multiple thinking strategies to examine* ***real-world issues, explore creative avenues of expression, solve problems, and make consequential decisions.***

5. **Clarify purpose and perspective.** *Explore* ***one's life purpose and meaning*** *through transformational experiences that foster an understanding of* ***self, relationships****, and* ***diverse global perspectives****.*

6. **ractice citizenship.** *Apply principles of* ***ethical*** *leadership,* ***collaborative engagement****,* ***socially responsible behavior****,* ***respect for diversity*** *in an interdependent world, and a service-oriented commitment to advance and sustain local and* ***global communities****.*

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Course Description

Title of Course: Group Discussion **Course Code: CE781**
L-T –P Scheme: 0-0-3 **Course Credits: 2**

A group discussion aims at a structured but informal exchange of knowledge, ideas, and perceptions among the participants on any issue, topic or sub-topic. Contributions are pooled together and examined in terms of their relevance and validity to the discussion objectives. If planned and organized in a structured way and certain essential conditions are met, it can provide a highly enriching and stimulating experience to the participants. Lets us see, the objectives, different steps involved in it and its limitations.

Objectives of a Group Discussion

- Produce a range of options or solutions, addressing a particular problem or an issue.
- Generate a pile of ideas by examining issues in greater depth, looking at different dimensions of these issues.
- Broaden the outlook of the participants through cross-fertilization and exposure to new and different experiences and ideas and enrich their understanding of the issues under discussion.
- Develop their skills in interpersonal communication and in expressing their views in a clear and succinct manner.
- Effective means of changing attitudes through the influence of peers in the group
- Valuable means of obtaining feedback for the training team on verbal skills, motivation level and personal traits of the participants and characteristics of the group

Steps in organizing a Group Discussion

- Setting up the Groups
- Planning a Group Discussion
- Preparation of Group Reports
- Presentation and Consolidation of Group Reports

Limitations

- If the group is large, not all the members may get the opportunity to participate and contribute to the discussion.
- If the task is not clearly defined, the discussion may lack focus and, as a result, it may be unproductive.
- Difficulties can arise if the leader is unskilled in guiding the discussion and/or not familiar with the topic or the issues.
- Some members may dominate and, in a way, hijack the discussion.

Course Description

- As this is a group task, some members may take it easy and not feel constrained to participate.

Learning outcomes

After studying this course, you should be able to:

- understand the key skills and behaviours required to facilitate a group discussion
- prepare effectively before facilitating a meeting
- consider some of the difficult behaviours that can occur in meetings
- think of some possible strategies for dealing with these.

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Course Description

Title of Course: Project Part- I **Course Code: CE781**
L-T –P Scheme: 6P **Course Credits: 4**

Project: an activity where the participants have some degree of *choice* in the outcome. The result is complete and functional, that is, it has a beginning, middle and end. Usually, it spans multiple lab periods and requires work outside scheduled lab periods. Since there are choices in implementation, *design* is inherently a component of a project. A project is inherently different from an *analysis* or *exercise*, in which the solution has a predictable form. Projects span a wide variety of possibilities: design and build, identify a system, do a forensic analysis, evaluate a product or assess some environmental situation.

Program Objective 1
Graduates shall make their way to the society with proper scientific and technical knowledge in mechanical engineering.

Program Objective 2
Graduates shall work in design and analysis of mechanical systems with strong fundamentals and methods of synthesis.

Program Objective 3
Graduates shall adapt to the rapidly changing environment in the areas of mechanical engineering and scale new heights in their profession through lifelong learning.

Program Objective 4
Graduates shall excel in career by their ability to work and communicate effectively as a team member and/or leader to complete the task with minimal resources, meeting deadlines.

Program Outcomes:

1. Ability to apply knowledge of mathematics, science and mechanical engineering fundamentals for solving problems.
2. Ability to Identify, formulate and analyze mechanical engineering problems arriving at meaningful conclusions involving mathematical inferences.
3. Ability to design and develop mechanical components and processes to meet desired needs considering public health, safety, cultural, social, and environmental aspects.
4. Ability to understand and investigate complex mechanical engineering problems experimentally.
5. Ability to apply modern engineering tools, techniques and resources to solve complex mechanical engineering activities with an understanding of the limitations.
6. Ability to understand the effect of mechanical engineering solutions on legal, cultural, social, public health and safety aspects./li>

Course Description

7. Ability to develop sustainable solutions and understand their impact on society and environment.
8. Ability to apply ethical principles to engineering practices and professional responsibilities.
9. Ability to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings.
10. Ability to comprehend, design documentation, write effective reports, make effective presentations to the engineering community and society at large.
11. Ability to apply knowledge of engineering and management principles to lead teams and manage projects in multidisciplinary environments.
12. Ability to engage in independent and life-long learning in the broad context of technological changes and advancements.