UNIT-I

INTRODUCTION TO MATERIALS TESTING.

1, OVERVIEW OF MATERIALS :-

* A material is defined as a substance (most often a solid, but other condensed phases can be included) that is intended to be used for certain applications.

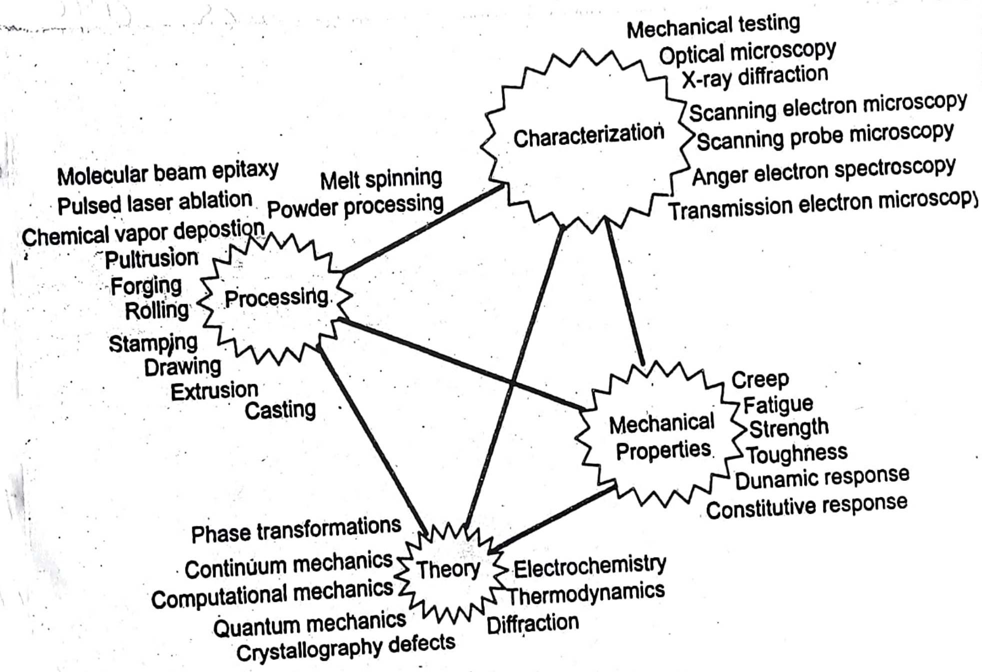


Fig. 1.1. Role of material testing

* materials are generally be further divided into two classes
  - crystalline
  - Non-crystalline.

* classification of materials
  - Metals
  - ceramics
  - polymers

* Bonding in solids.
  - Primary bond
  - Secondary bond.

* Structure in crystalline materials.

Metals and ceramics are composed of aggregations of small grains, each of which is an individual crystal. In contrast, glasses have an amorph-ous or non-crystalline structure.

* Defects in crystal:
  - ceramic and metals in the form used for Engineering applications are composed of crystalline grains that are separated by grain boundaries.
  - Defects occurring are classed as line defects or surface defects.

MATERIAL TESTING:-

Material testing are established technique which is used to ascertain both the physical and mechanical properties of raw material and components.

→ CLASSIFICATION:

- Mechanical testing (or) Destructive testing.
- Non-destructive testing.
- Material characterization testing.

↳ Destructive testing:

Destructive testing is a form of object analysis that involves applying a test to break down a particular material to determine its physical properties such as the mechanical properties of strength, toughness, flexibility and hardness.

- classifications : * Static testing
  * Impact testing
  * cyclic testing.

↳ Non-Destructive testing:

Non-destructive testing (NDT) consist of a variety of non-invasive inspection techniques used to ev... material properties, components, or entire process units. The unique can also be utilized to detect, characterize or measure the presence of damage mechanisms.

* Major sources of NDT test.

- Liquid
- Radiation
- Sound.
- Magnetism
- Infrared.

↳ Material characterization testing:

Characterization and analytical techniques are methods used to identify isolate or quantify chemicals or materials or to characterize their physical properties.

Characterization of samples used for external techniques to analysis into the sample's elemental composition, internal structure and thermal, electrical, magnetic properties etc.

PURPOSE OF TESTING:-

* To maintain the quality and consistency of the finished product.

* To avoid mistakes in the first stage of the manufacturing process.

* To obtain compliance certification by following guidelines and regulations of testing and by obtaining standard limit of materials properties.

* To ensure that the materials are suitable for production and usage.

* To determine the reason behind product failure during manufacture while in use.

* To prevent failure in usage.

* Used as a quality control check in in the material manufacturing or processing. Destructive testing is used to check the quality, durability, specific requirement and non-destructive test used for finding defect.

* For the acceptance of materi[al]
the component performance would
fulfil the requirement of testing.

* To check the components prior the
final assemble.

* To check the component in service
without damage and deterioriation

* Used for research and development
of existing and new materials.

4, SELECTION OF MATERIALS:

Material selection is one of the
foremost functions of effective
engineering design as it determines
the reliability of the design in terms of
industrial and economical aspects.

a) Steps to be considered for selection
of materials.

* Identify the design requirement

The design requirement includes

* performance requirements.
* simplicity and practicability
* Reliability requirements.

* Size, shape and mass requirements.
* cost requirements.
* Manufacturing and assembly requirements.
* Industry standards.
* sustainablity requirements.

* Identify materials selection criteria
* Identify candidate materials.

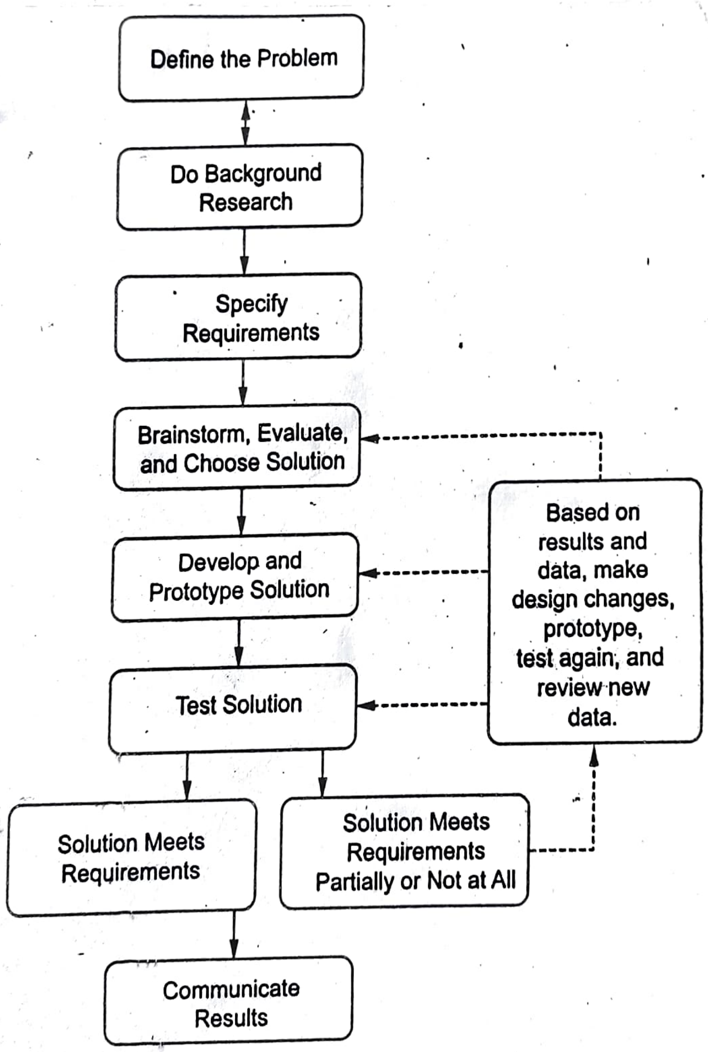


Fig. 1.8. Failure analysis

* Evaluate candidate material.
* select material.
* Failure analysis.
* service experience.

(b) Factors affecting selection of materials.

* Performance.
    - Mechanical properties
    - wear of materials
    - corrosion
    - Ability of manufacture.
    - cost.
* Reliability and Environmental resistance.
* Reducibility.

Material selection cannot be made independently of the selection of the manufacturing process, since the manufacturing process will afect the performance properties of materials.

In addition one must take into account the geometric attributes of the productions.

5. DEVELOPMENT OF TESTING:

materials testing, measurement of the characteristics and behavior of such substances as metals, ceramics or plastics under various conditions by a full or small scale model of a proposed machine or structure may be tested.

Standard test method have been established by such national and international bodies as the ISO.

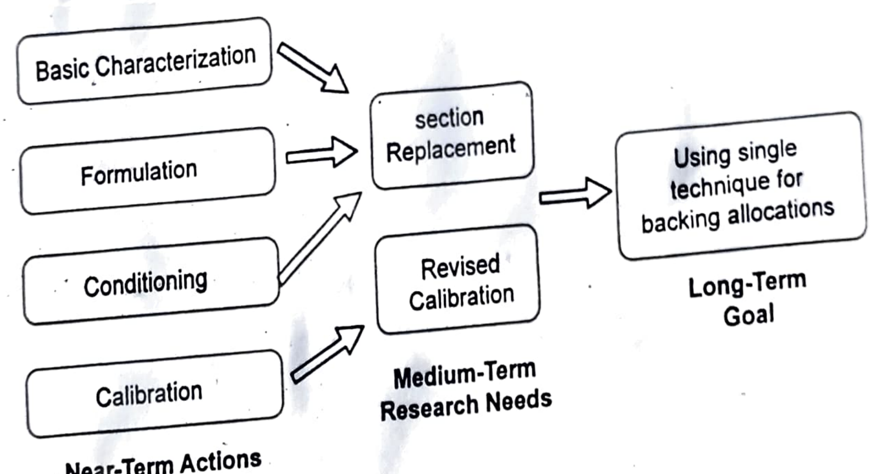
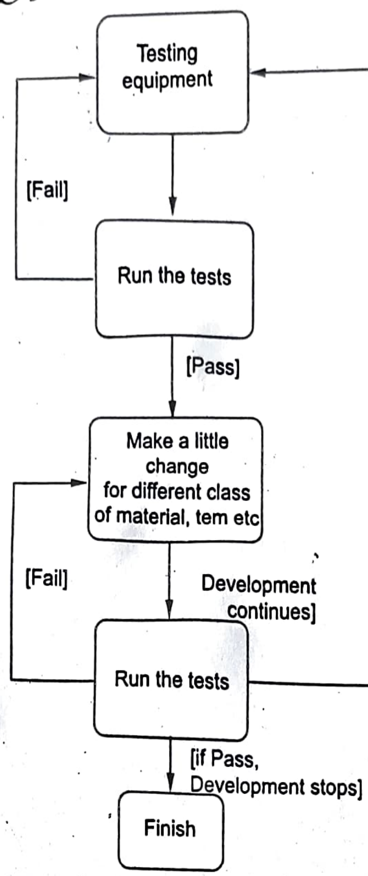


Fig. 1.9. Formulation in test development

a) stages in development of testing.

* Identify the need & define the problem.
* Research the problem.
* Develop possible testing method.
* Evaluate the alternatives & select most promising methods.

* Initial design.
* construct a prototype.
* Test and evaluate the prototype



* … design.
* Redesign.

Example for development of testing.

* Development of mechanical testing
* Development of static compression
* Development of static shear and bending test.
* Development of measures of ductility
* Development of hardness testing

TESTING ORGANIZATIONS AND ITS COMMITEE.

* International organization for standardization
* ASTM International.
* BUREAU Of Indian Standards.
* organization of BIS
* organization chart
* Other testing organizations
* codes for test procedures.

For all the tests described in this the method as specified is relevant ISO standard may also be followed as an alternate method. The final value, observed or calculated, expressing the result of a test analysis, is rounded off in accordance with IS:2-1960. The number of significant places retained in the rounded off value should be the same that of the specified value in the code.

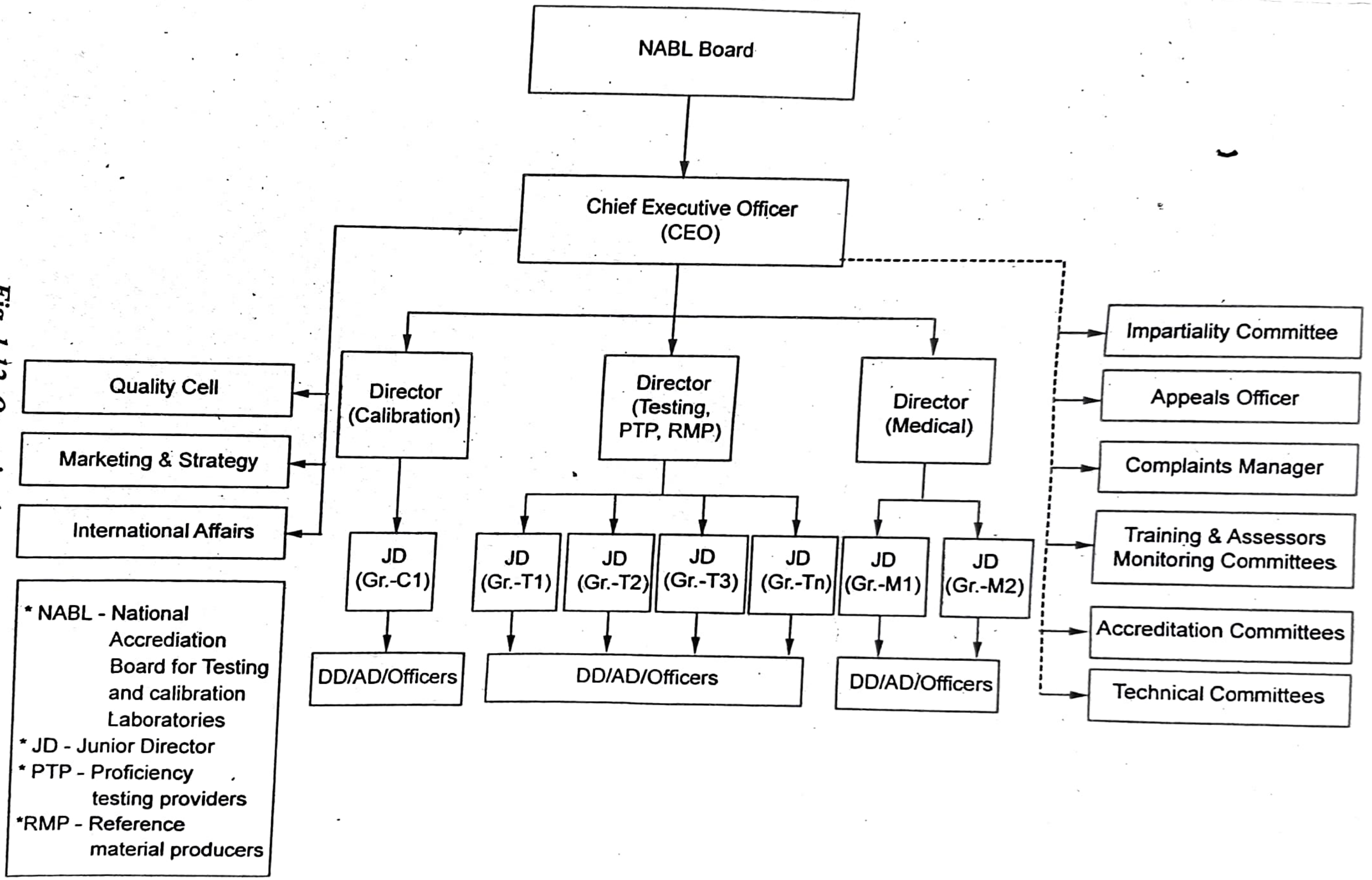


Fig. 1.12. Organization chart

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BENEFITS OF TESTING:

* Safety issues can be identified.
* It provides reliability.
* It is cost effective.
* It offers reassurance.

The test are carried out to ensure product safety, and also to make sure the person carrying out the work on any machinery or components is safe too. In mechanical the equipment testing area is covered with glass plate to prevent from shattering of test piece out of equipment.

Test are can also insight that can result in the effective replacement or repair of components or equipment before a real malfunction or breakdown occurs, which will save more money in the long terms.

The operation of testing equipment being harmless and it also help to prevent injury or fatalities by structure, machinary etc.

8. PRESENTATION OF RESULT:

It is very important by sharing the knowledge of result or develop with others which leads to various development of test result by scientist or researchers.

* Statements of the problem.
* Materials, methods and procedure used during testing.
* Data presentation and result analysis.
  - charts and graphs.
  - Tabulations
  - Statement.
* Analytic software.
* Summary, conclusion and discussion
* Appendies to support findings.

Example:

* Biovia materials studio.
* Las x materials science modules.
* Matlab.
* Auto cad.
* Stadd pro.
* Abacus.

TESTING Vs INSPECTION:

Testing is the physical performance of an operation series aimed at providing quantitate data regarding the properties of a material. It provides the information about the quality of material.

Inspection is the observance of a material to determine the presence or absence of a desired one. It aimed about the controlling the quality of material by establishing criteria of acceptance or rejection.

10, PRECISION Vs ACCURACY:

The accuracy of an experiment, object or value is a measurement of how closely results aggre with accepted value. The degree of conformity and correctness of something when compared to a true or absolute value. single factor or measurement.

The precision of an experiment object or value is a measurement reliability and consistency. A state of strict exactness - how or something is strictly exact. Multiple measurement or factors are needed.

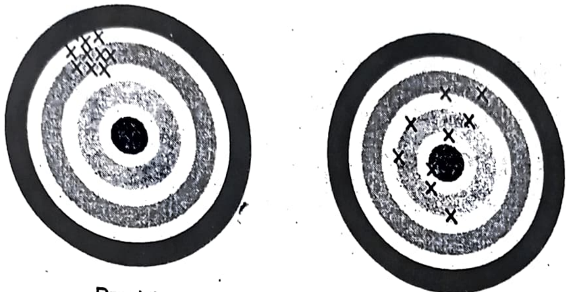

Fig. 1.14. Precision vs. Accuracy

UNIT-II

MECHANICAL TESTING

1. INTRODUCTION TO MECHANICAL TESTING:

The study of deformation and fracture in material is called as mechanical behavior of materials. Knowledge of this area provides the basis for avoiding these types of failure in Engineering applications. One aspect of the subject is the physical testing of samples of materials by applying.

→ Mechanical properties of materials

1. MECHANICAL PROPERTIES OF MATERIAL

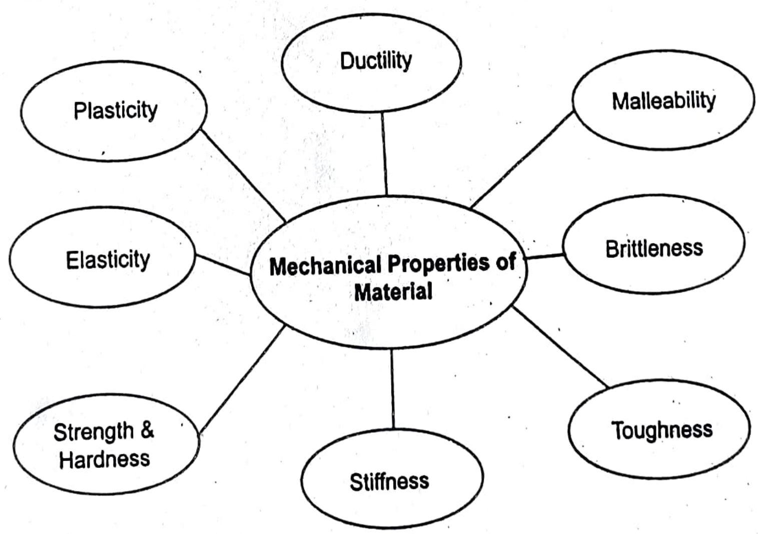

Fig. 2.1. Mechanical properties

* Strength & hardness.
* Stiffness
* Elasticity
* Plasticity
* Ductility
* Brittleness.
* Malleability.
* Toughness.
* Resilience

→ property based testing method.

→ Material failure.

  * Deformation failure.
  * Fracture failure.
    - Brittle or ductile fracture.
    - Environmental cracking failure.
    - Corrosion fatigue.
    - fatigue crack growth.
    - creep rupture.
    - High-cycle fatigue & low cycle fatigue.

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HARDNESS TEST:

* Hardness:

The term hardness is a structure sensitive mechanical property material primarily associated with the surface. If a material is uniform in composition and structure, the hardness measured on the surface layer will represent the hardness of the bulk of the material.

* classification of hardness.
    * Indentation hardness.
    * Rebound hardness.
    * scratch hardness.
    * wear or abrasion hardness
    * cutting hardness.

* Mohs scale.
* Indenter.
* selection criteria of hardness tester.
    * test load.
    * hardness range.
    * Accuracy level.
    * Adaptability of the device.

* Benefit of hardness test:
  * Easy
  * Inexpensive
  * quick.
  * Non-destructive.
  * may be applied the samples of various dimensions and shapes.
  * may be performed in-situ

3. BRINELL HARDNESS TEST:

The Brinell hardness test consist of forming an indentation by forcing a standard spherical ball indenter into a surface of the material.

The standardized method for quantitative method for indentation hardness, which was the first widely accepted indentation hardness test known as Brinell hardness test.

In this test a hardened steel ball of 2.5, 5 or 10mm in diameter is used as indenter:

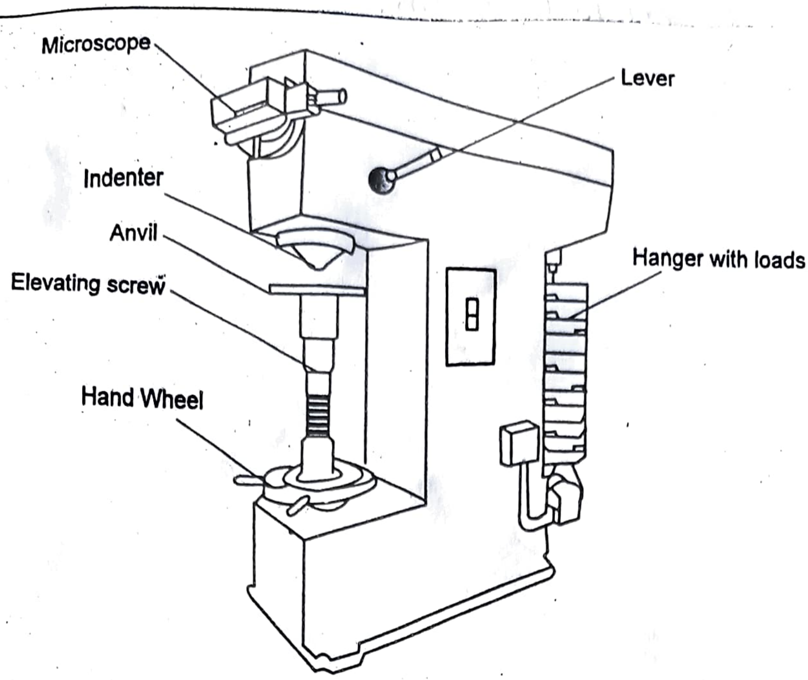


Fig. 2.5. Brinell tester with components

*PRINCIPLE:

An indenter is forced into the surface of a test piece and the diameter of indentation, 'd' left in the surface after removal of the surface. 'F' is measured under a definite static load applied for a standard period of time.

*Major components:

- Brinell hardness tester.
- Brinell microscope.
- Indenters and plunger.
- Anvil.

* Indentors

* Load application.

* working.

* Brinell Hardness Number (BHN)

The Brinell hardness number (BHN) expressed in units of kilogram per square millimeter, is defined as the ratio of the applied load to the curved surface area of the elastically indentation.

$$H_B = \frac{F}{Area}$$

$$Area = \frac{\pi D}{2}\left[D - \sqrt{D^2 - d^2}\right]$$

$$H_B = \frac{2F}{\pi D\left[D - \sqrt{D^2 - d^2}\right]}$$

$$h = \frac{1}{2}\left[\frac{D}{D^2 - d^2}\right]$$

* Behaviour of deformation

* Error in the reading

* Advantages.

* Disadvantage.

ROCKWELL HARDNESS TEST:

In the rockwell test the depth of the indenter penetration into the specimen surface is measured. Each time a test is performed two loads are applied to the sample being tested.

* principle:

Rockwell hardness test is to determine the hardness of a metal by 'differential depth' measurement test. This hardness testing method

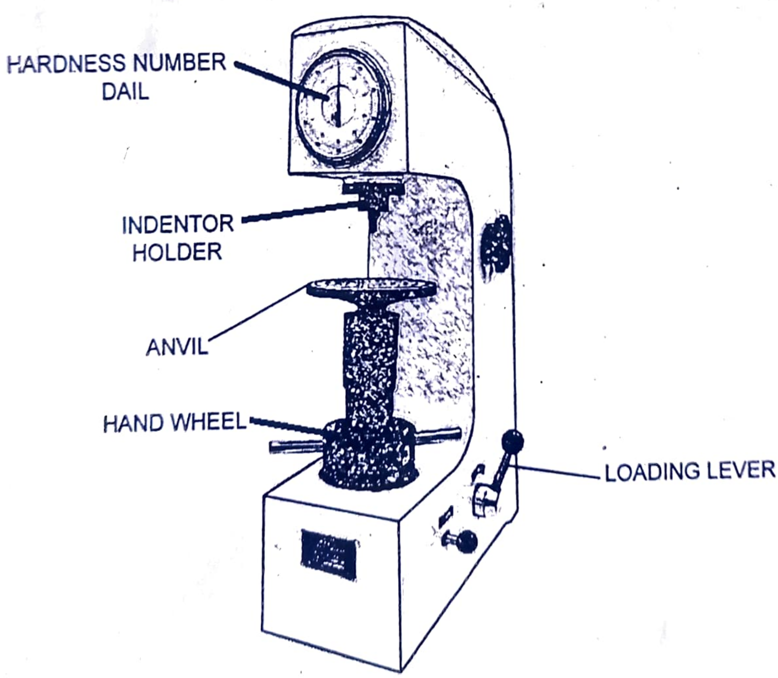


Fig. 2.8. Rockwell hardness tester

* components.

  Rockwell hardness tester

  Indenter

* Indenter.

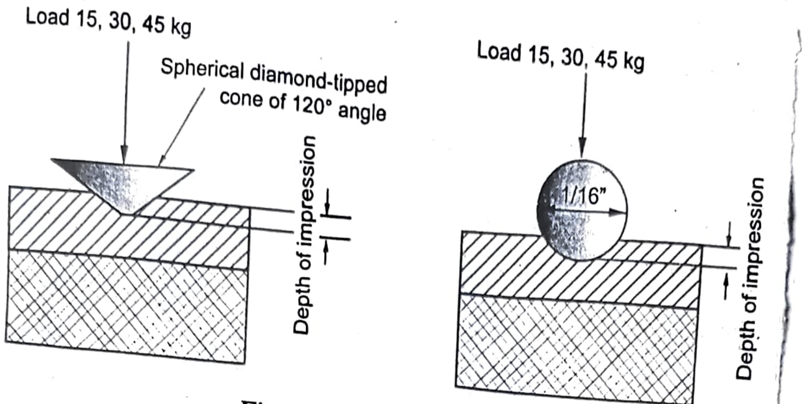


Fig. 2.9. Types of indenter

* Loading condition

  minor static load.

  Major static load.

* working

* Rockwell hardness scale.

* Applications

* Advantages.

* Disadvantages.

* Advantages over Vickers

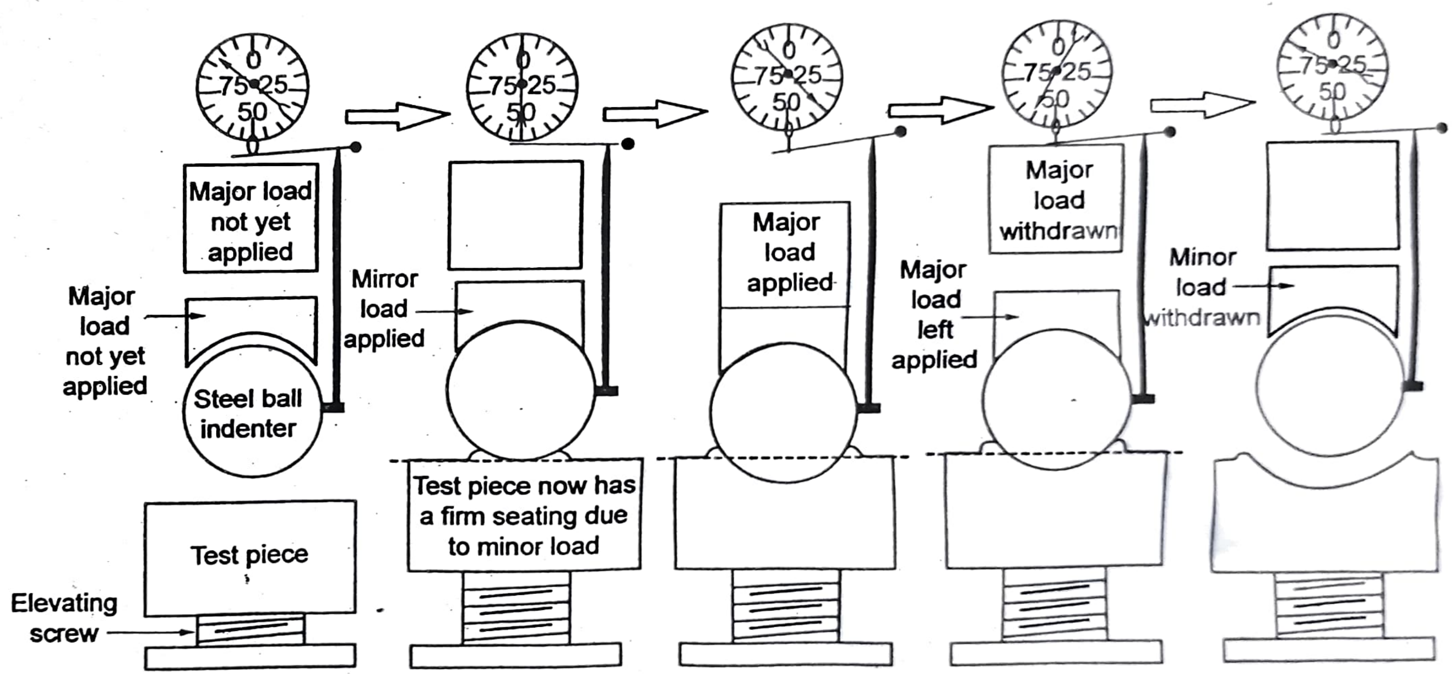


Fig. 2.10. Process of loading

5, VICKER HARDNESS TEST: *

The Vickers hardness test, was to determine quantitatively the indentation hardness of material under the application of a constant static load, is the widly accepted method for research work because it is capable of measuring hardness from very soft materials to extremely hard material without changing the load or indenter.

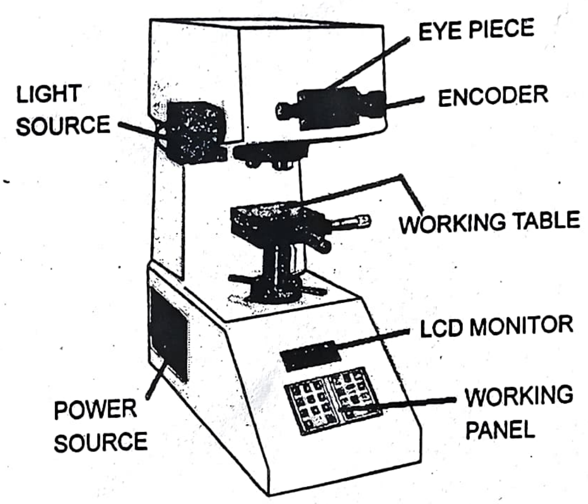


Fig. 2.11.Vickers hardness tester

* principle :

A diamond indenter in the form of a right pyramid with a square base with a specified angle between opposite faces at a vertex is forced into the surface of a test piece followed by measurement of a diagonal length of the indentation left in the surface after removal of the test force F.

* components.

Vickers hardness tester.

Intender.

* Intender.

* Loading condition

* working

* Vickers hardness number.

$$VHN = \frac{P}{As} \text{ kg/mm}^2$$

$$= \frac{P}{D^2/1.854}$$

$$VHN = 1.854 \times \frac{P}{D^2}$$

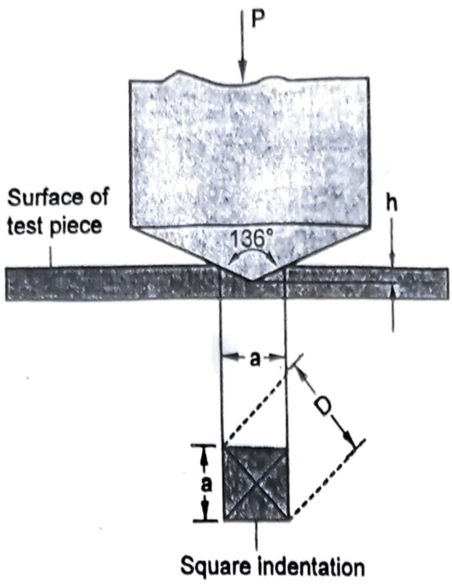


Fig. 2.12. Vickers diamond indenter

* Advantage.
* Disadvantages.

6, KNOOP HARNESS TEST:

The quantitative determination of hardness on materials over a very small area under the application of a constant static load, the diamond indenter known as the 'knoop' indenter and hardness test is called knoop hardness test.

7, MONOTRON HARDNESS TEST:

The monotron hardness test also operates on the depth of the indentation is fixed or predetermined under the

NANO- HARDNESS TEST:

Nano hardness tests or nano-indentation tests in which the magnitudes of applied forces are usually in the milli - newton range, may be as low as 0.1mN, Majority of nano indentation tests aim to Young's modulus along with measurement of hardness of the specimen materials from load-displace-ment data obtained in test.

9, COMPARISION B/W ROCKWELL, BRINELL, VICKER

2.9. COMPARISON BETWEEN ROCKWELL TEST, BRINELL TEST AND VICKERS TEST

Properties	Brinell	Rockwell	Vicker
Indenters	Hard metal	Steel ball or diamond cone	Square-based pyramid diamond indenter with a 136° included angle
Load	Typically 1kg to 3000kg	30-100 kg	Typically 10g to 1,000g
Duration	15- 30sec	10-15 sec	30-60 sec
Advantages	Simple surface preparation, easy measurement	Higher speed, immediate reading, shallow imprint.	The test specimen can be used for other purposes.
Disadvantages	Impression is large with visible trace	Possibility of cone breakage	Surface preparation is needed

10. TENSILE TEST:

* principle:

A standardised specimen with known cross section is loaded uniformly with relatively low increasing force in the longitudinal direction.

* Equipment:

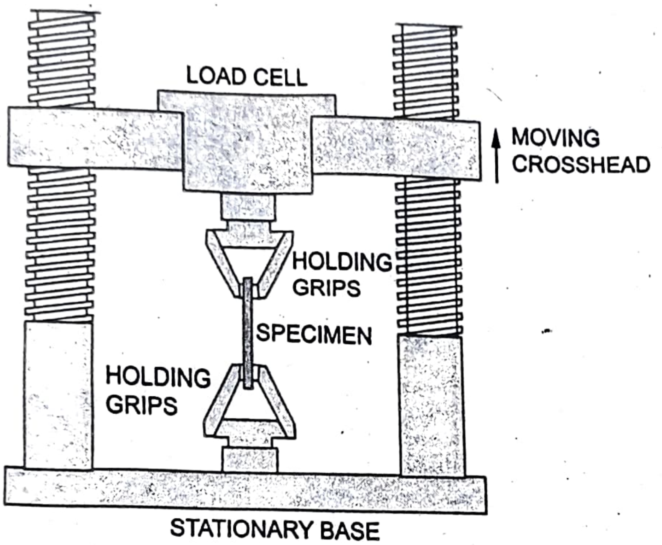


Fig. 2.13. Tensile testing apparatus

* universal testing machine.

It is capable of force capacity from 500 N to 1 MN. The strain measurements are measured with an extensometer.

* Entensometer.

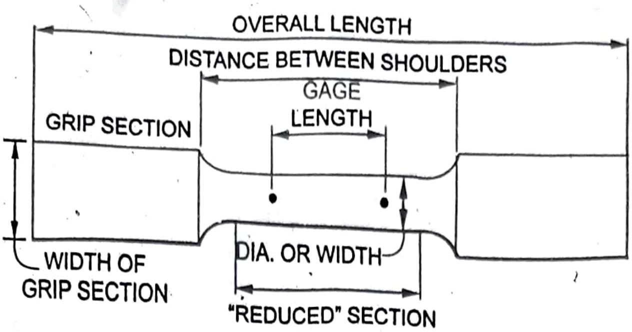


Fig. 2.14. Sample Tensile Specimen

* working
* Derived properties:

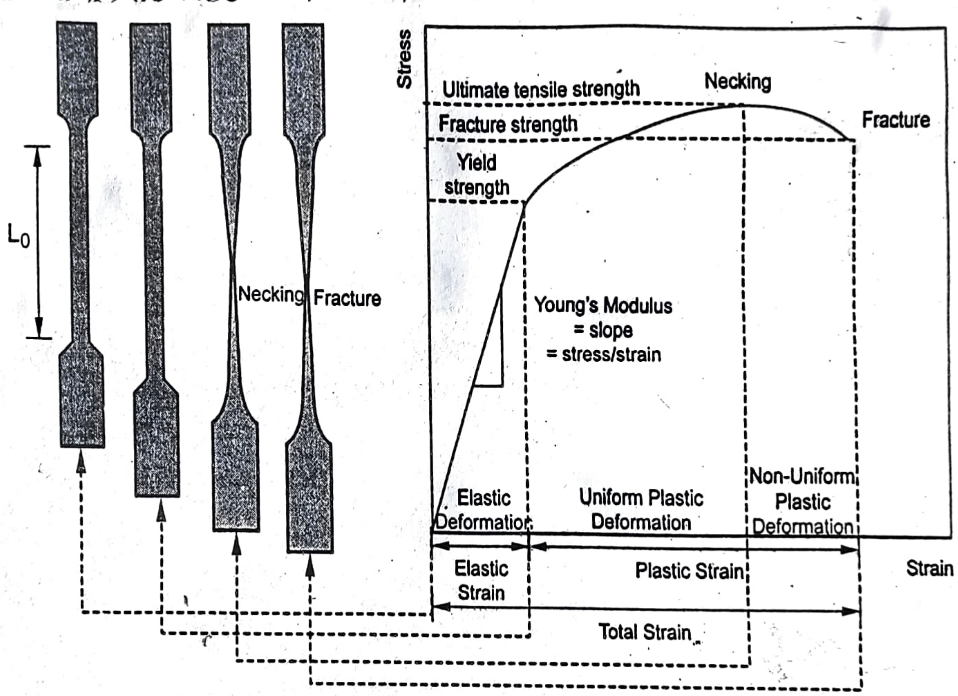


Fig. 2.16. Stress strain curve of mild steel

* Factors affecting tensile testing
* varies form of tensile test.
* Advantages.
* Disadvantages.

11. IMPACT TEST:

* methods of impact testing
* purpose of impact testing.

12. IZOD & CHARPY TEST:

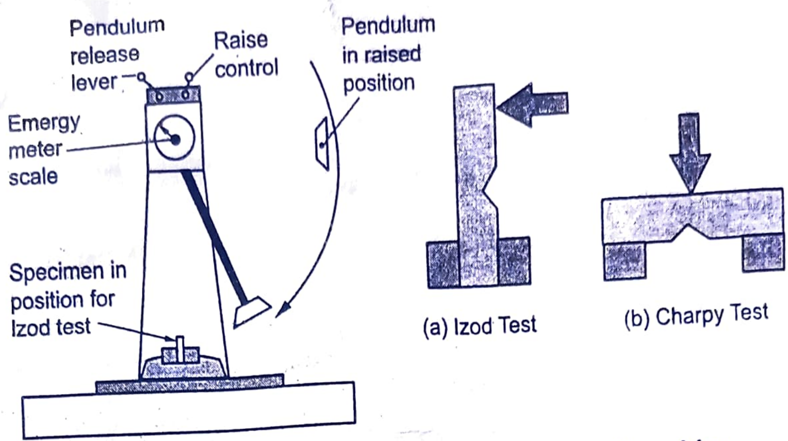


Fig. 2.17. Pendulam impact machine and notch position

* principle
* working
* Applications
* Advantages.
* Disadvantags.

COMPARISION B/W IZOD IMPACT & CHARPY IMPACT TEST

Parameter	Izod impact test	Charphy impact test
Notch face	Facing the striker, fastened in pendulum	Face is positioned away from the striker
Materials used	Plastics and metals	Metals
Holding	It imitates cantilever beam	It imitates simply supported beam
Temperature	It is largely affected by temperature changes	It shows minimum error to temperature changes
Calculation	The Izod impact value (J/m, kJ/m^2) is calculated by dividing the fracture energy by the width of the specimen.	The Charpy impact value (kJ/m^2) is calculated by dividing the fracture energy by the cross-section area of the specimen.
Energy	The fracture energy is determined from the swing-up angle of the hammer and its swing-down angle	The fracture energy is determined from the swing-up angle of the hammer and its swing-down angle.

14. BEND TEST.

* *

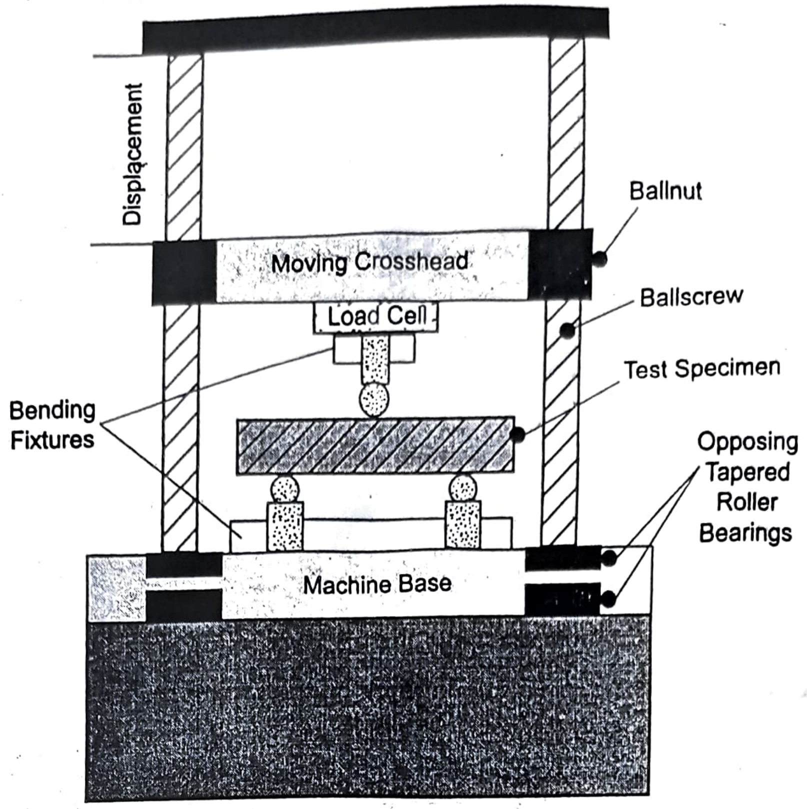


Fig. 2.18. Bending test equipment

* principle.

* Method of bend test based on load position.

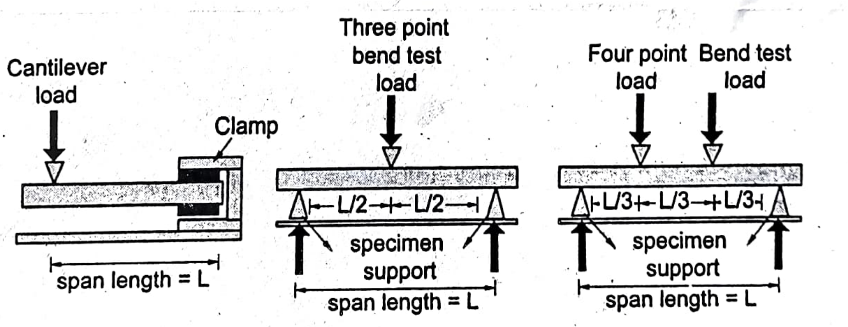


Fig. 2.19. Cantilever, 3-point and 4point Load position

* working
* Derived properties
* Factors affecting the modulus the rupture.
* Advantages.
* Disadvantages.

15. SHEAR TEST:

* Principle
* Types of shear test:
  Single shear test
  Double shear test:
* components.
* shear fixtures.

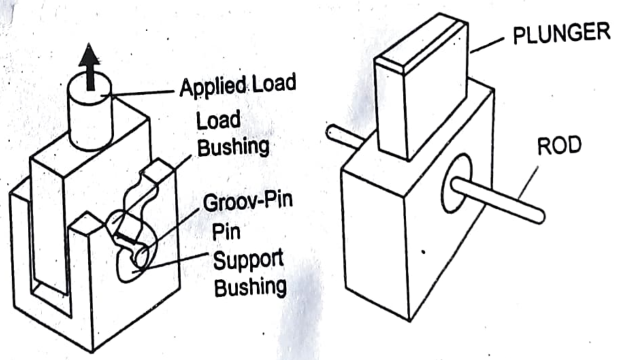


Fig. 2.20. Layout of shear fixtures

* single & double shear test.

* working

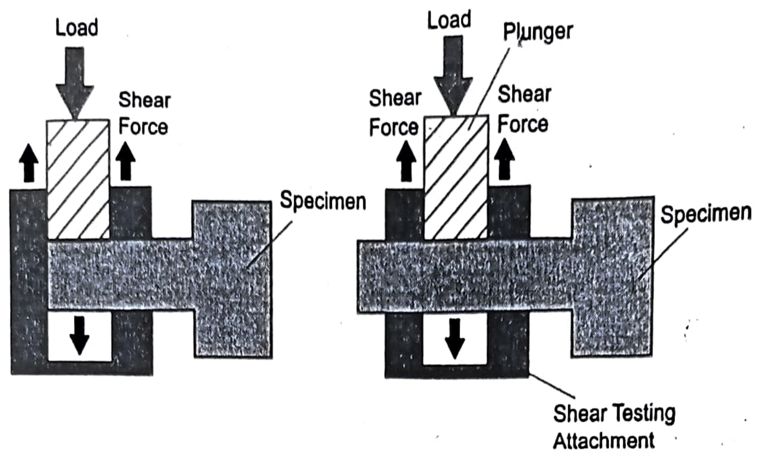


Fig. 2.21. Single and double shear loading

* Advantage.
* Limitations.

16, CREEP :

* creep test.
* stages of creep.
    * (1°) primary.
    * secondary (2°)
    * Teritary (3°)
    * ultimate ductile failure

* procedure.
* Mechanism of deformation.
* methods to reduce creep.
* Advantage.
* Limitations.

FATIGUE TEST:

* principle.
* Method to determine fatigue life.

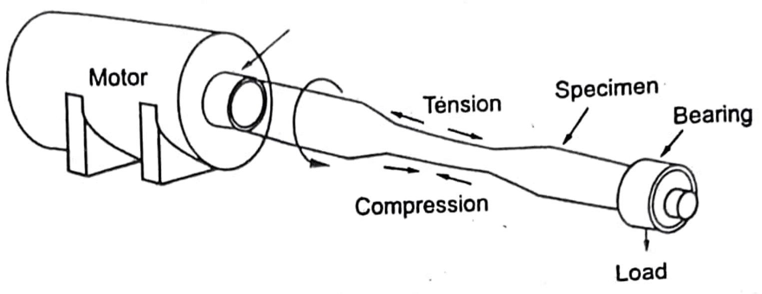


Fig. 2.24. The cantilever type fatigue testing

* working.
* stages in fatigue failure.
  - 1 - crack initiation
  - stage 2 - crack propagation
  - stage 3 - crack fracture.

* S-N curve.

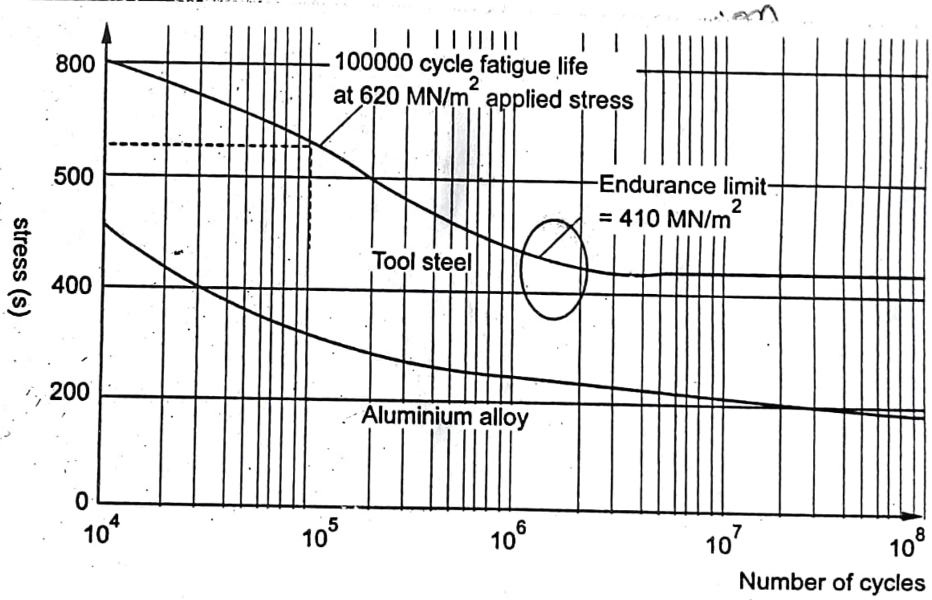


Fig. 2.25. S-N curve for steel and aluminum alloy

* Derived properties.

$$R = \frac{\sigma_{min}}{\sigma_{max}}$$

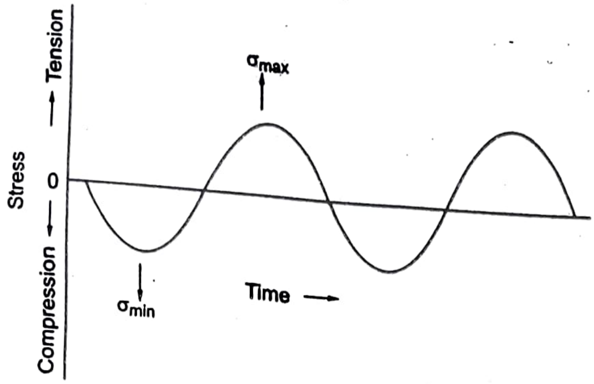


Fig. 2.26. Compression and tension flow cycle

* ... cle.
* Low-cycle fatigue.
* Factor influce the fatigue limit.
* methods to reduce fatigue.
* Advantages.
* Disadvantages.

UNIT-III

NON-DESTRUCTIVE TESTING.

1. OVERVIEW OF NDT.

* Importance
* Advantage.
* Stages of working in NDT
  - Testing
  - Recording & reporting
  - Interpretation & Evaluation

Testing
↓
Recording
↓
Reporting
↓
interpretation
↓
Evaluation.

2, Non-destructive methods :

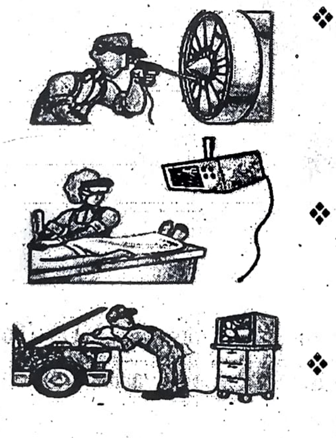
* comparision of NDT :

Table 3.1. Comparison of NDT Capabilities

Technique	Capabilities	Limitations
Visual Inspection	Macroscopic surface flaws	Small flaws are difficult to detect, no subsurface flaws.
Radiography	Subsurface flaws	Smallest defect detectable is 2% of the thickness; Need radiation protection.
Dye penetrate	Surface flaws	No subsurface flaws; Not used for porous materials
Ultrasonic	Subsurface flaws	Material must be good conductor of sound.
Magnetic Particle	Surface / near surface and layer flaws	Limited subsurface capability, only for Ferromagnetic materials.
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 equipment.

* visual testing

3.2.1. VISUAL TESTING (VT)



Page 3.5

* principle.
* Environment for visual inspection
* Types of visual inspection
  - Unaided visual inspection
  - Aided visual inspection

* Defects.
* Types of unaided viewing.
* The commonly using visual aids
* Materials factors that affect visual testing.

* Advantage.
* Disadvantage.
* Application.
* Example of some application visual testing.

* Liquid penetrant test.
* principle.
* Surface preparation.
* Basic processing steps of a liquid penetrant inspection.

2. Basic Processing Steps of a Liquid Penetrant Inspection

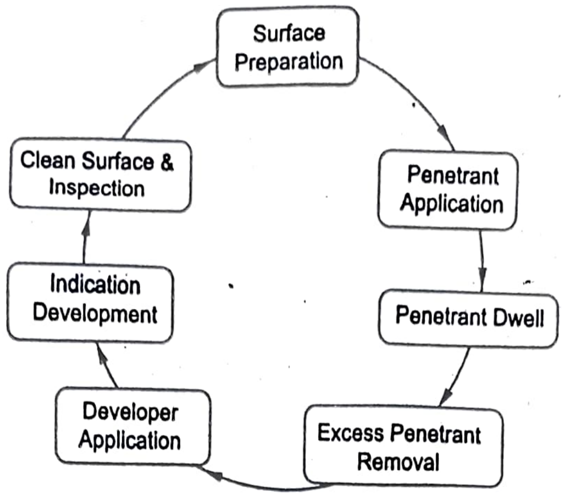


Fig. 3.3. Flow chart in basic process of Liquid Penetrant Inspection

* Penetrant application
* penetrant Dwell.
* Excess penetrant Removal.
* Developer applicant.
* indication Development.
* Inspection.
* clean surface.
* Advantage.
* Disadvantage.
* Application
* penetrant.
* Developers

* Six standard forms of developers.

* magnetic particle testing

*

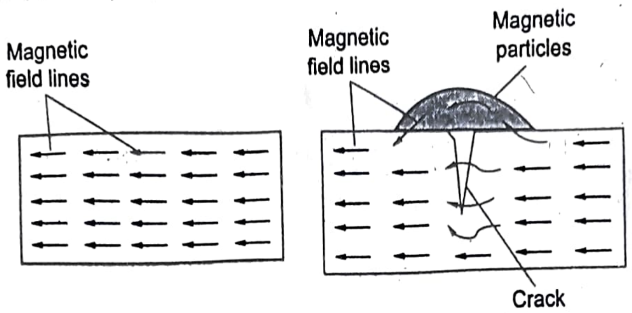


Fig. 3.9. Principle of working

* magnetic properties of materials.

Hysteresis loop

permeability

Types of magnetisation

Longitudinal magnetisation.

* components of magnetic inspection
* working of magnetic particle testing

COMPONENTS IN MAGNETIC PARTICLE INSPECTION (MPI)

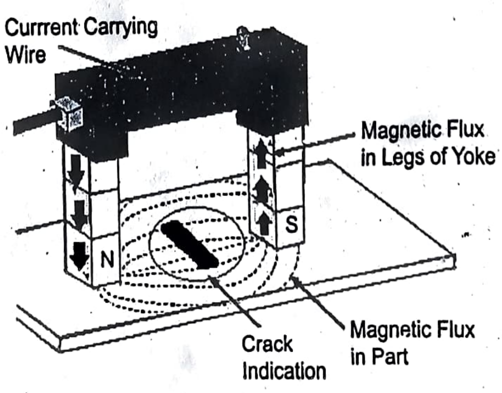


Fig. 3.15. Components of magnetic particle testing

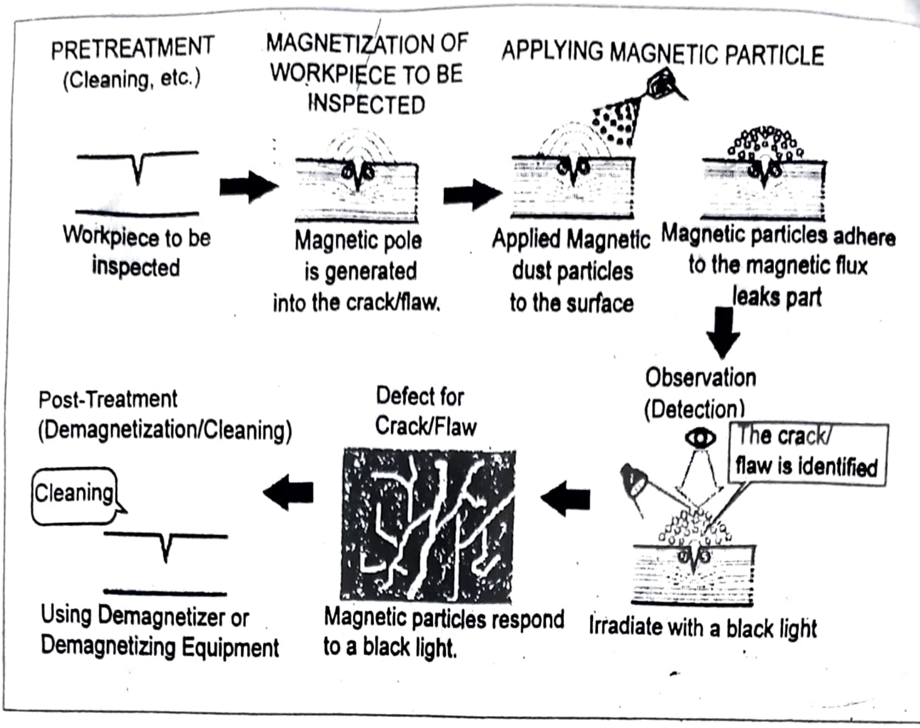


Fig. 3.16. Nature of finding flaws

* Advantage.
* Disadvantage.
* Applications.

Thermography test.

* Principle
* Types of thermography.

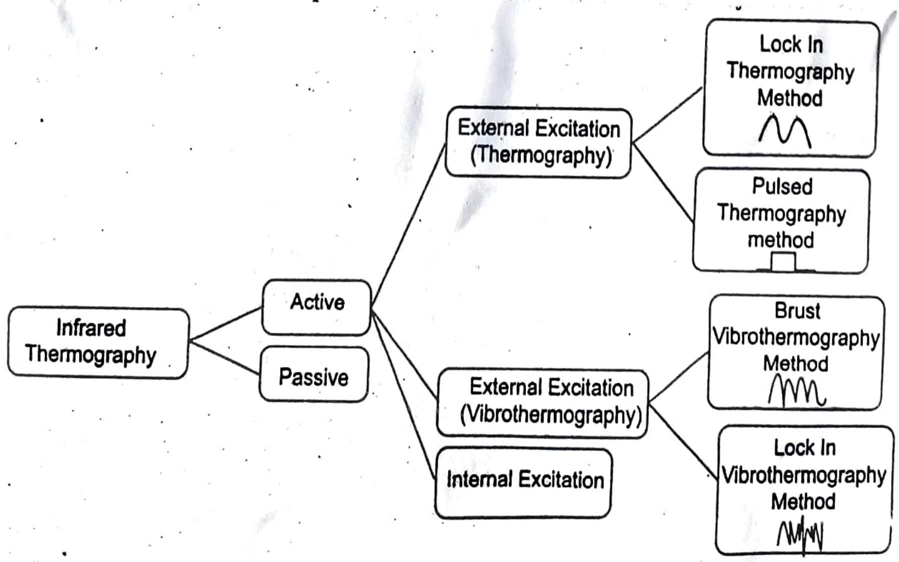


Fig. 3.17. Types of Thermography

* Basis aids or components in thermography

* working.

a) burst vibrothermography method

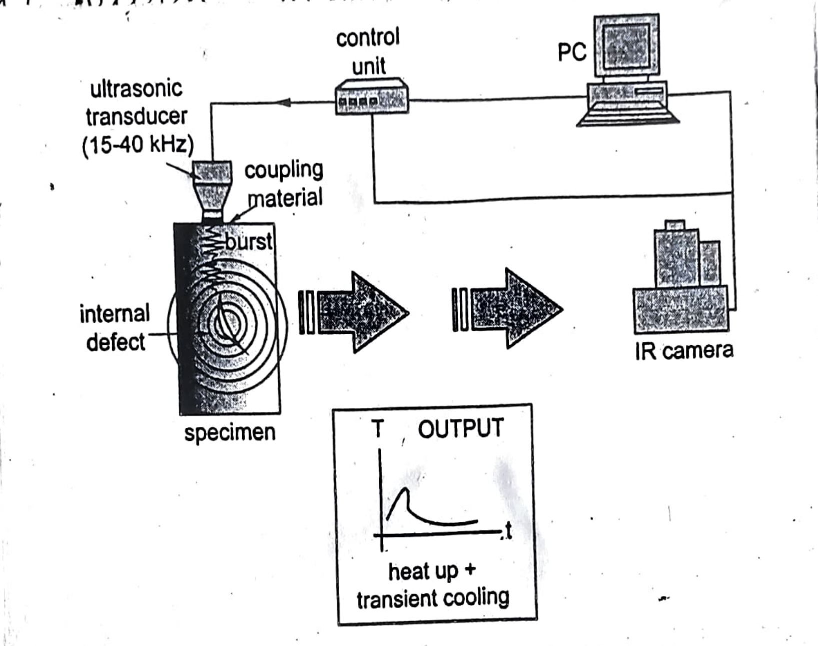


Fig. 3.18. Burst Vibrothermography Method

b) Lock in vibrothermography method.

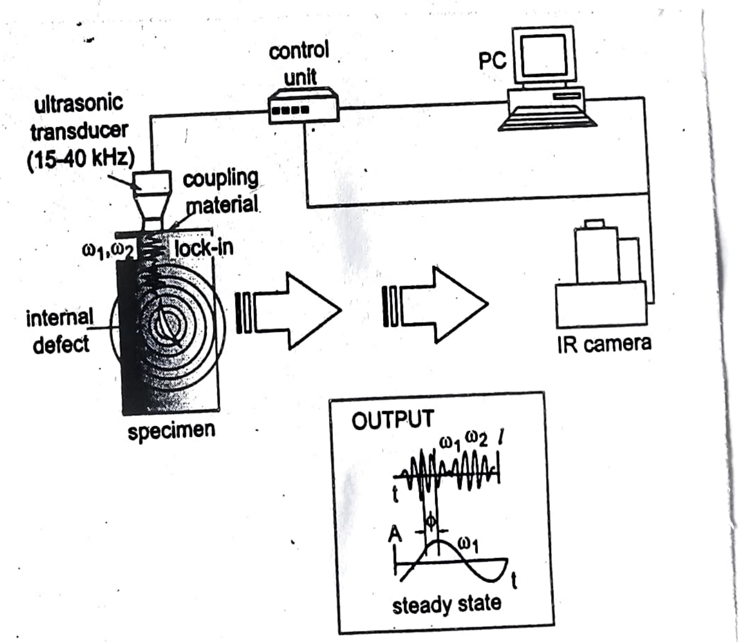


Fig. 3.19. Lock In Vibrothermography Method

c) Lock in thermography.

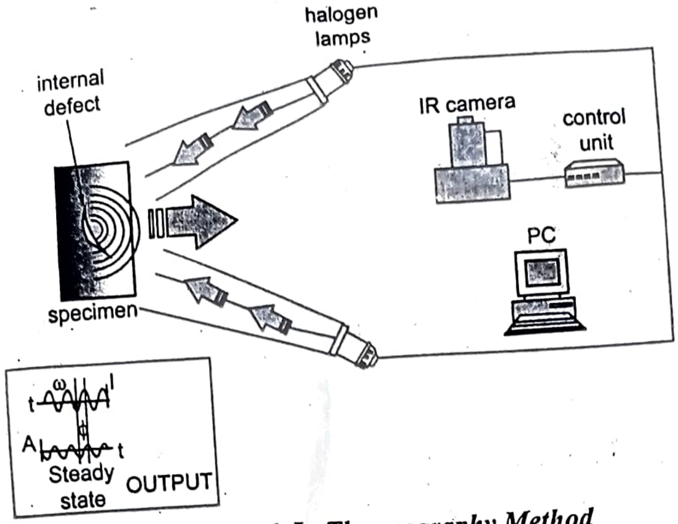


Fig. 3.20. Lock In Thermography Method

d) Pulsed thermography.

(d) Pulsed Thermography method

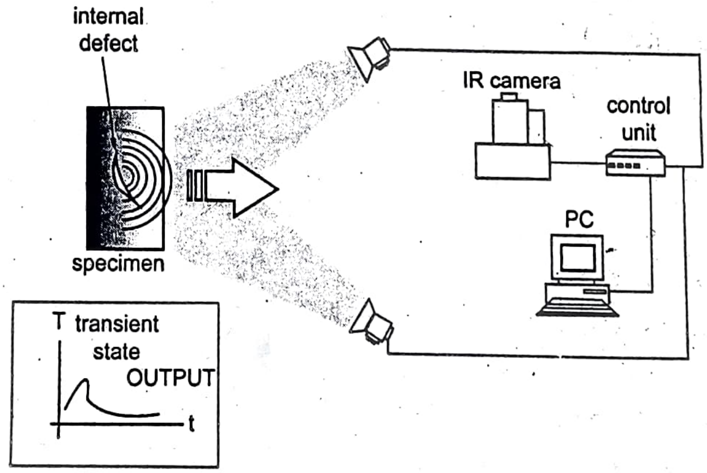


Fig. 3.21. Pulsed Thermography method

7. Radiographic Testing:

Types of Radiographic testing.

2. TYPES OF RADIOGRAPHIC TESTING

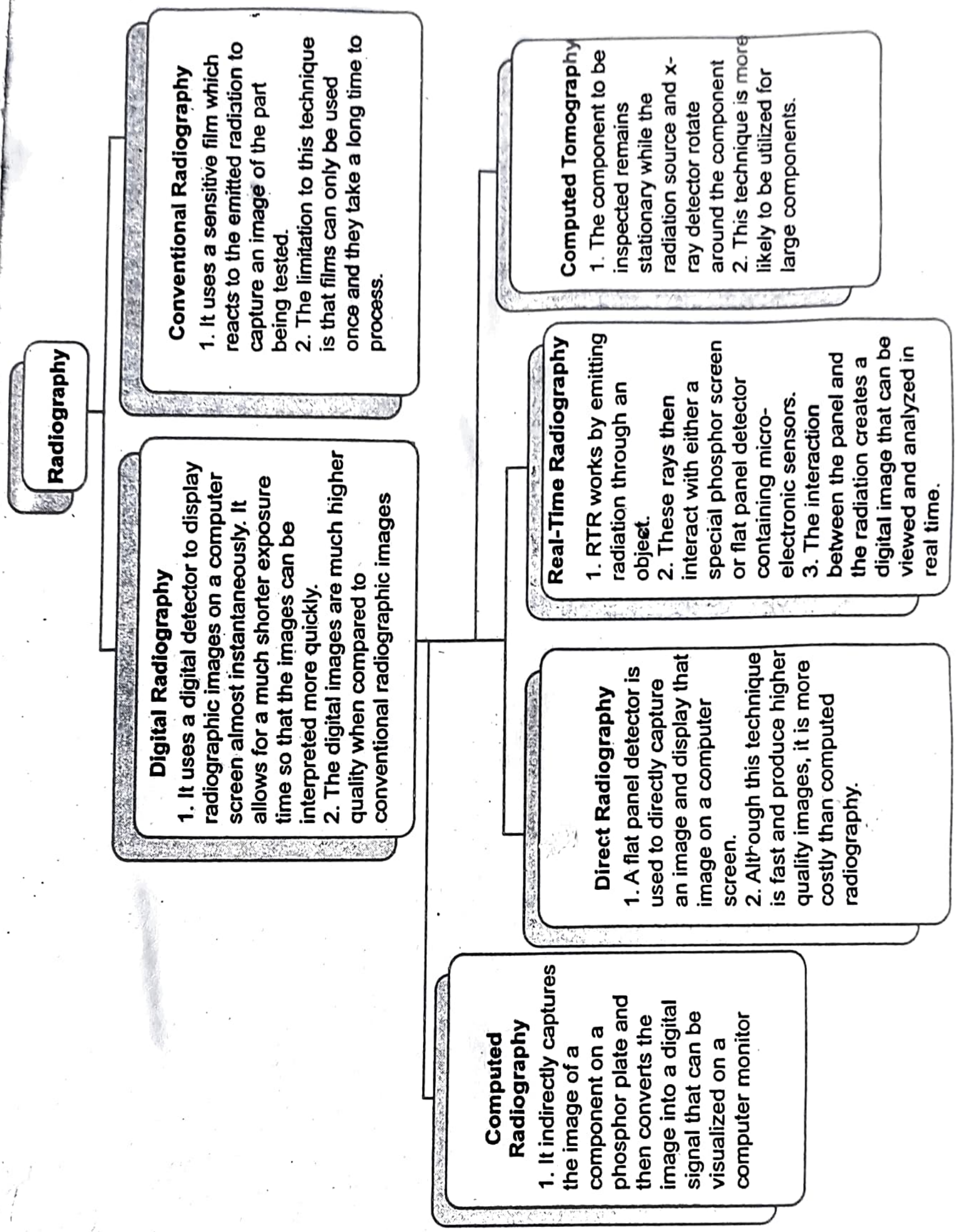


Fig. 3.23. Types of Radiography Testing

* principle.
* source components.
* working
* Radiograph film.

* Safety aspects of radiation te
* Advantages.
* Disadvantages
* Limitation.

8. Electromagnetic testing.

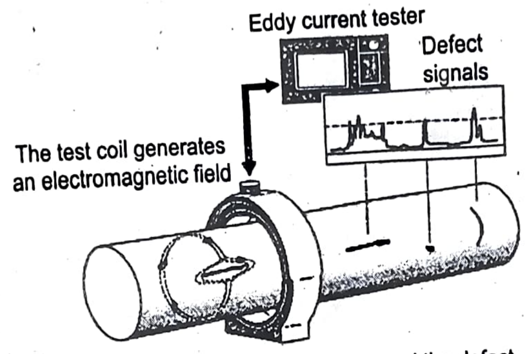


Fig. 3.25. Eddy current tester

Principle:

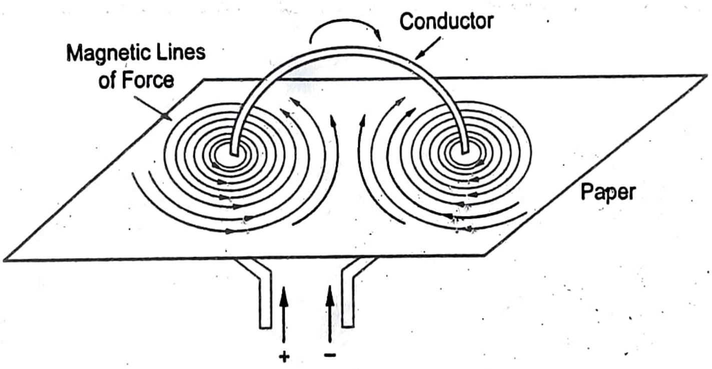


Fig. 3.26. Principle of eddy current flowing

Methods.

2. METHODS OF EDDY CURRENT TESTING

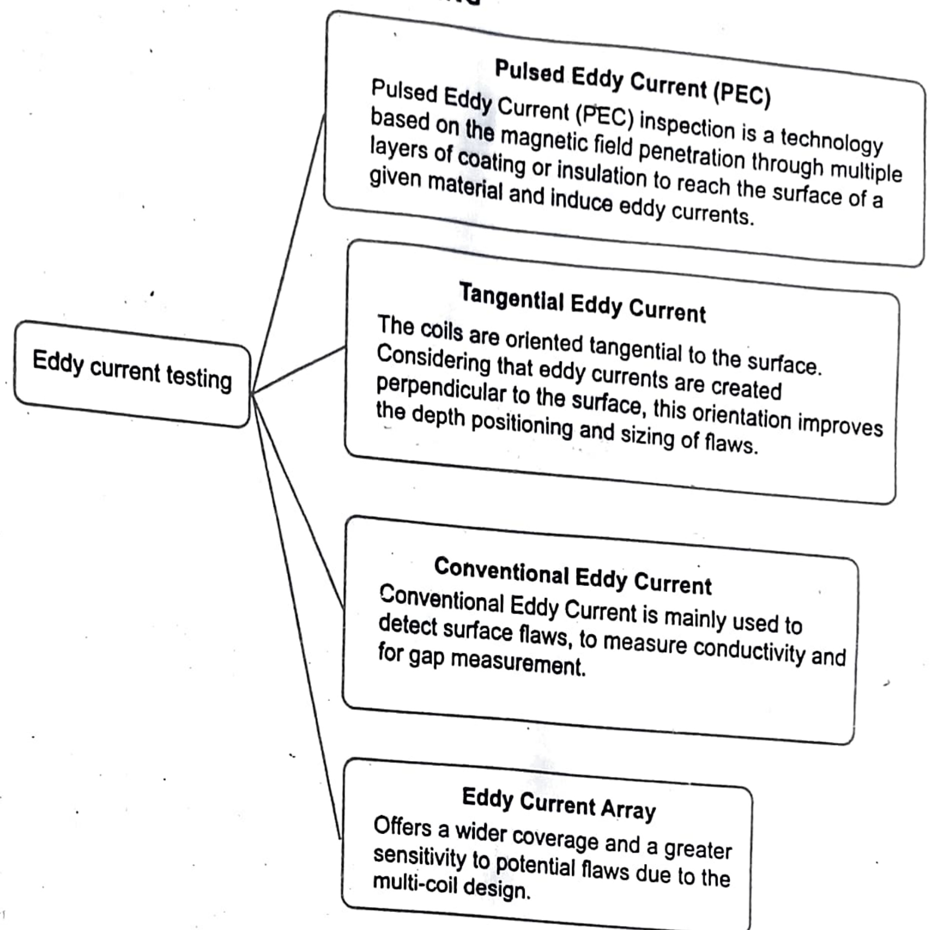


Fig. 3.27. Types of eddy current testing

components of eddy current.

working.

The strength of the eddy current.

Factors that affect the eddy current

Advantages

Disadvantages.

Applications

9, Eddy probe.

Types of eddy current probe.

Design of probe.

10, Ultra sonic testing.

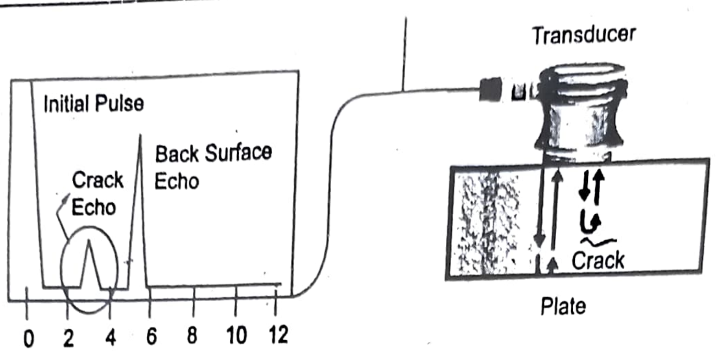


Fig. 3.29. Ultrasonic testing set up

principle.

Basic components.

Data interpretation

Method in ultrasonic testing

working.

Advantages

Disadvantages

Applications

11, Acoustic Emission.

principle.

Basic components in acoustic emission

working.

Advantage.

Disadvantage.

12. Selection of NDT

Reliability of non destructive testing

Table 3.2. Relative uses and merits of various nondestructive testing methods

Test method	Ultrasonics	X-ray	Eddy current	Magnetic particle	Liquid penetrant
Capital cost	Medium to high	High	Low to medium	Medium	Low
Consumable cost	Very low	High	Low	Medium	Medium
Time of results	Immediate	Delayed	Immediate	Short delay	Short delay
Effect of geometry	Important	Important	Important	Not too important	Not too important
Access problems	Important	Important	Important	Important	Important
Type of defect	Internal	Most	External	External	Surface breaking
Relative sensitivity	High	Medium	High	Low	Low
Formal record	Expensive	Standard	Expensive	Unusual	Unusual
Operator skill	High	High	Medium	Low	Low
Operator training	Important	Important	Important	Important	Less important

UNIT-IV

MATERIAL CHARACTERIZATION TESTING.

1. OVERVIEW:

Characterization describes those feature of composition and structure of a material that are significant for a particular preparation, study of properties or use and suffice for reproduction of the material

classifications:

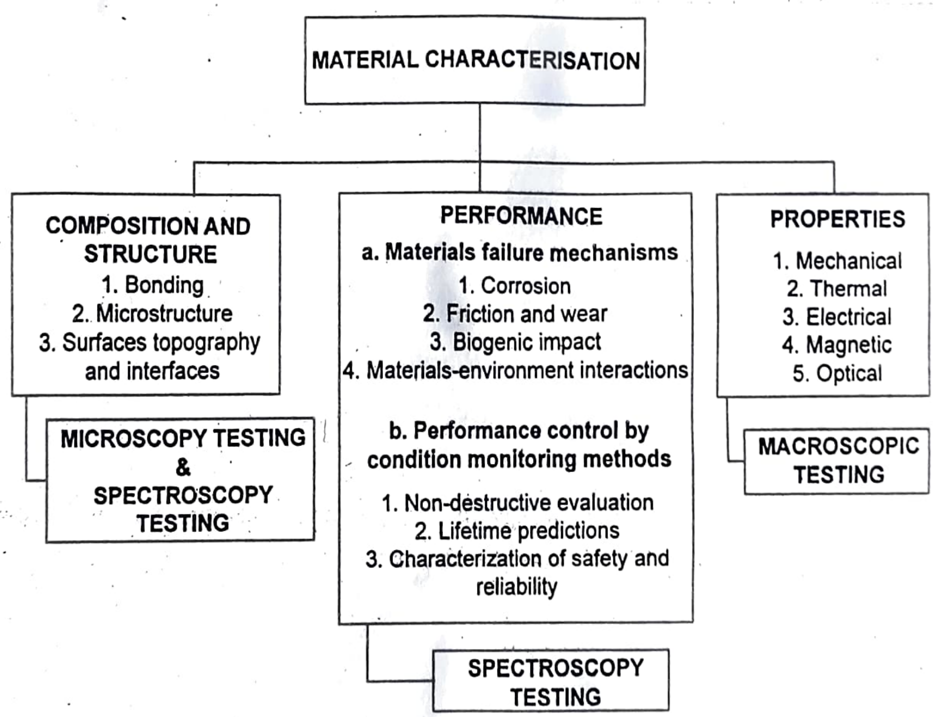


Fig. 4.1. Materials characterization chart

2, SCALE:

The scale of the structures observed material characterization ranges from angstroms such as in the imaging of individual atoms and chemical bonds, up to centimeters, such as in the imaging of coarse grain structures in metals.

3, MATERIAL CHARACTERIZATION TESTNG

- MICROSCOPY

microscopy is a technique that allows the determination of both the composition and the structure of a material.

- properties
- Instruments.

optical microscope.

SEM

TEM.

- Spectroscopy & nuclear spectroscopy.

This group of techniques uses a range of principles to reveal the chemical composition, composition variation, crystal structure and photoelectric properties of materials.

Macroscopy:

In which some physical and chemical changes are observed. In this changs can be observed by the naked eye

macroscopic properties.

Density

Volume

strength.

Hardness

Roughness.

3, Basic terminology.

Magnification:

Magnification on a microscope refers to the amount or degree of visual enlargement of a observed object or enlargement of image.

Resolution:

Defined as the ability to distinguish two very small and closely spaced objects as sperate entities.

Lens:

The obsowation magnification is the product of the magnification of each of the lenses. This generally ranges from 10x to 1000x with some models even reaching.

5, Optical microscope :

The optical microscope also reffered to as a light microscope is a type of microscope that commonly uses visible light and a system of lenses to generate magnified image of small objects.

Types :

Bright field microscope.
Dark field microscope.
Polarized light microscope.
Phase contrast microscope.
Digital microscope.

Other microscope types :

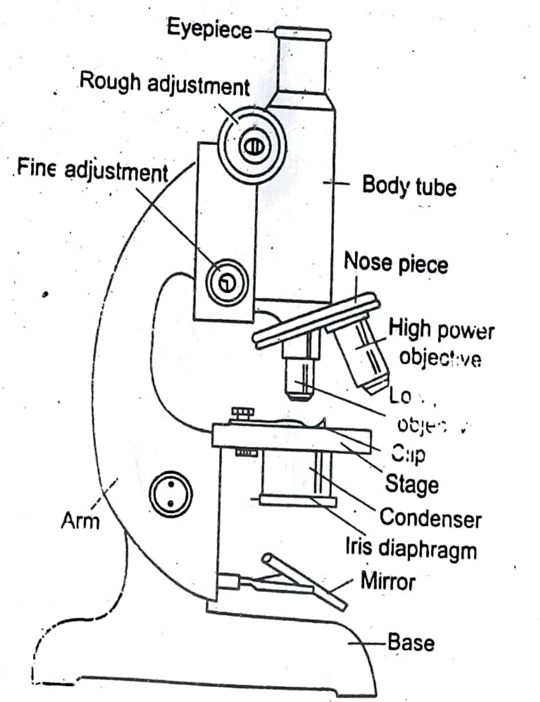


Fig. 4.2. Typical cross section of optical microscope

preparation of specimen.

working:

The stage moves up to down when you turn a thumb wheel on the side of the microscope. By raising and lowering the stage, you move the lenses closer to or further away from the object you're examining, focus of the image to see.

magnification

Advantages:

Disadvantage:

Resolution limit of optical microscope due to diffraction even the best classic optical microscope is limited resolution

Application

optical microscopy is used extensively in microelectronics, nanophysics biotech, pharmaceuticals,

6, Electron microscope:

A electron microscope is a microscope that uses a beam of accelerated electrons as a source of illumination.

Types :

Transmission electron microscope.

Scanning electron microscope.

T9 SEM :

A Scanning electron microscope uses a focused electro probe to extract structural & chemical information point by point on the speciemen. It use wide range of scale from nanometer to micrometer.

Principle :

A Scanning electron microscope uses a focused electro probe to extract structural

The electrons interact with atoms in the sample, producing various signals that contain information.

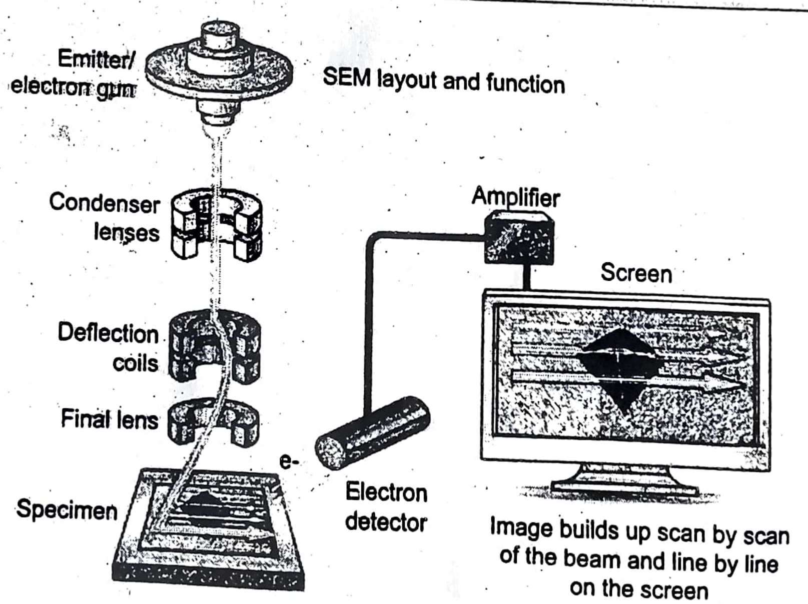


Fig. 4.3. Working nature of SEM

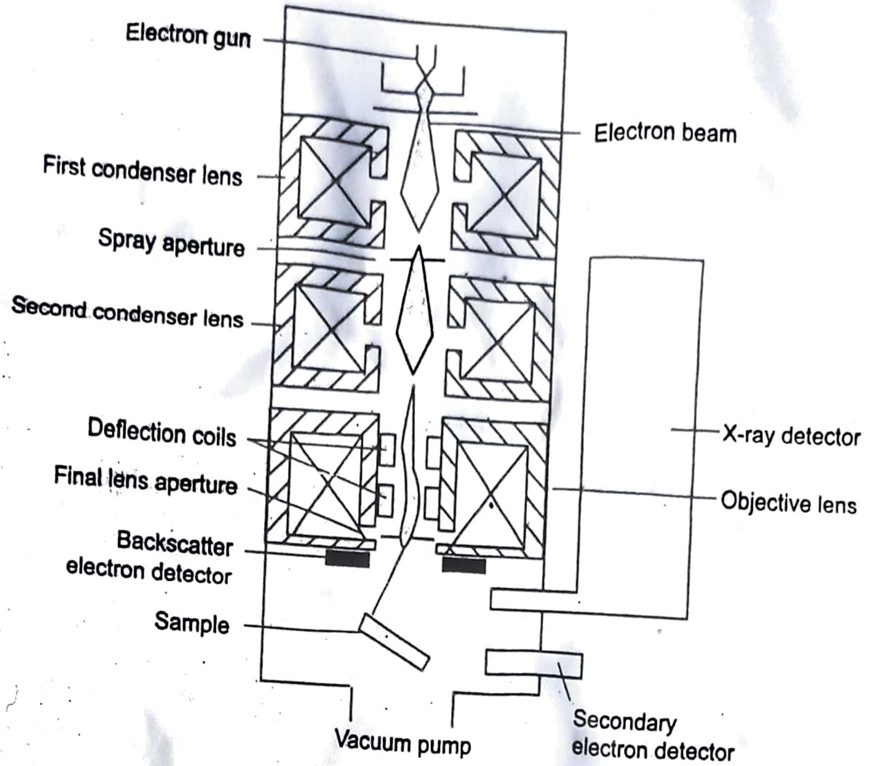


Fig. 4.4. Sectional view of SEM

* Components.
  - Electron gun
  - condenser lens
  - Vacuum chamber
  - Deflection coil.
  - Secondary electron detector.
  - specimen stage.

Specimen loading stage.

  - surface preparation
  - Mounting specimen
  - specimen coating

working of SEM.

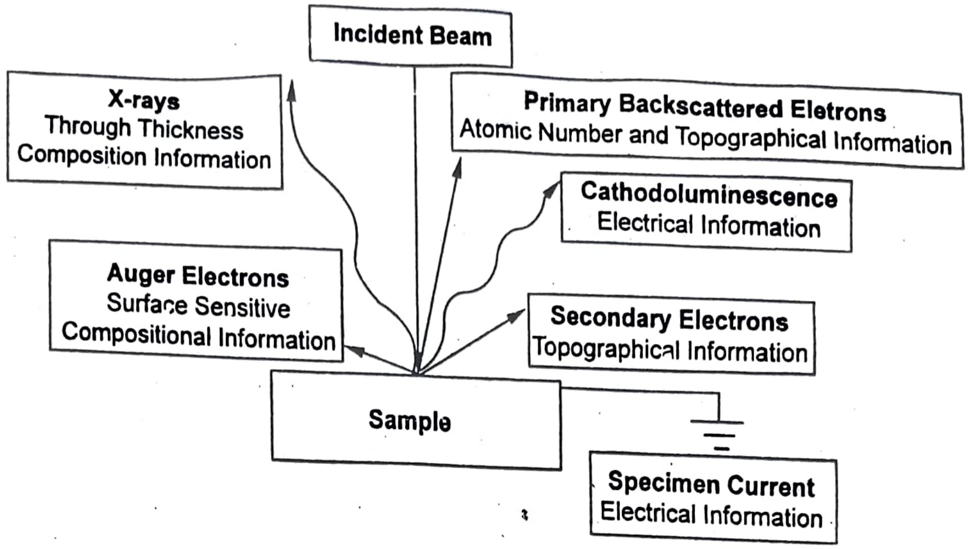


Fig. 4.5. Scattering Electrons

Applications:

The sem also excels in producing Ideal uses.

Advantage.

Versatile platform that supports many other analysis techniques.

Limitation:

Sem carry a small risk of radiation exposure.

Training is required to operate.

TEM:

TEM utilizes energetic electromagnetic to provide morphologic compositional & crystallographic information on samples. The transmitted electrons that have passed through sample are detected.

Principle:

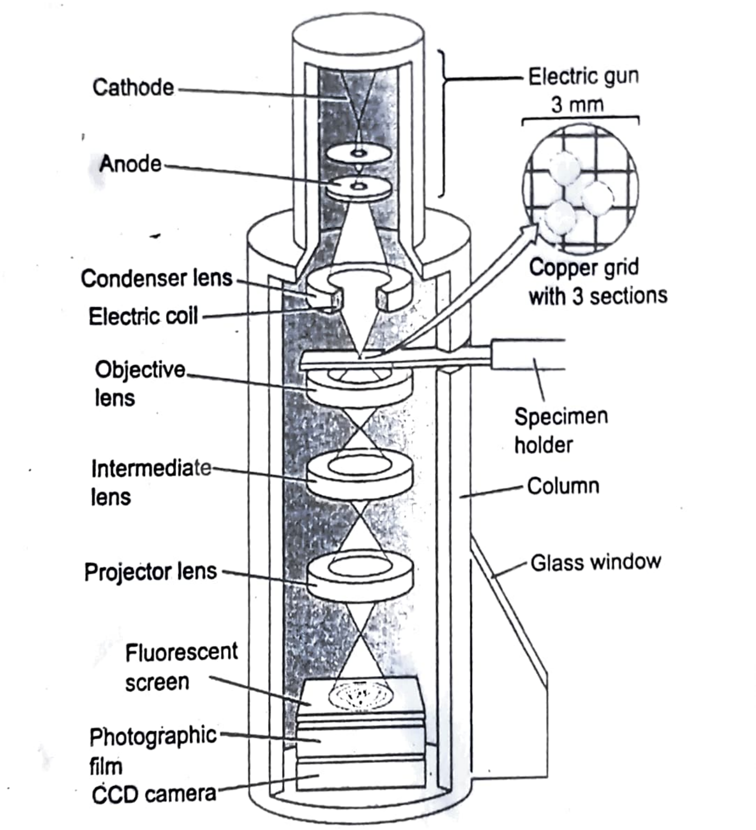


Fig. 4.6. Working of TEM

Method of specimen

ultra microtome.

ultra disc cutting

Dimpling

Ion milling

construction:

It consists of a electron gun. The speciemen is placed in between the condenser lens and the objective lens. The magnetic projector lens is placed above the fluorescent screen.

Components of TEM:

- Electron source.
- Electromagnetic lenses
- Vaccum chamber.
- Condenser.
- Sample stage.

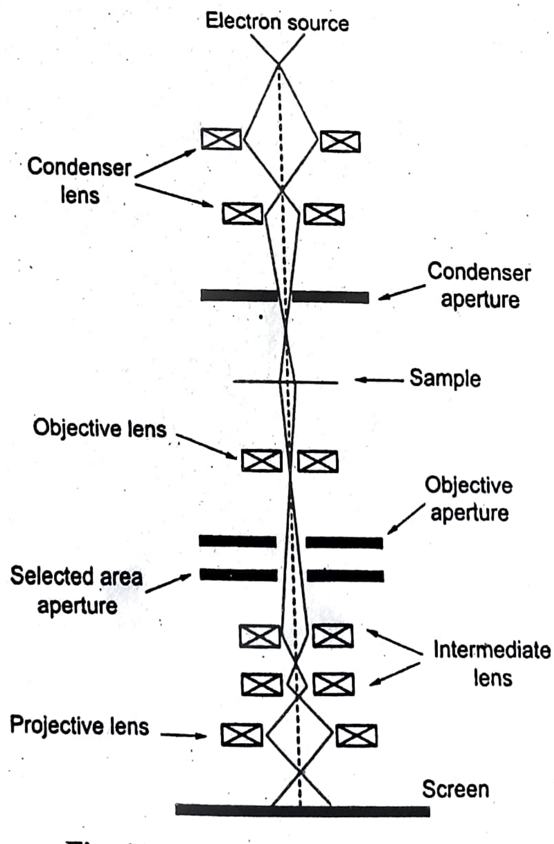


Fig. 4.7. Cross sectional view of TEM

The

Working:

An image of the specimen with its assorted parts shown in different shades. according to its density appears on the screen.

* Operation modes of TEM.

Two basic operation modes.

Imaging mode.

Diffraction mode.

* Resolution

TEMs can produce images with resolution down to 0.2nm. The true show structrural arrangement of atoms in the sample method.

* Limitation:

Laborious sample preparation

TEMs are large and very expension.

* Advantage:

TEM provide information on element and compound structure.

The highest spatial resolution elemental mapping of any analytical technique.

7. DIFFRACTION TECHNIQUE:

DIFFRACTION:

Diffraction refers to various phenomenon that occurs when a wave encounters an obstacle or a slit. It is defined as the bending of wave around the corners of a obstacle or trough an aperture into the region of geometrical shadow.

Principle:

Bragg's Law.

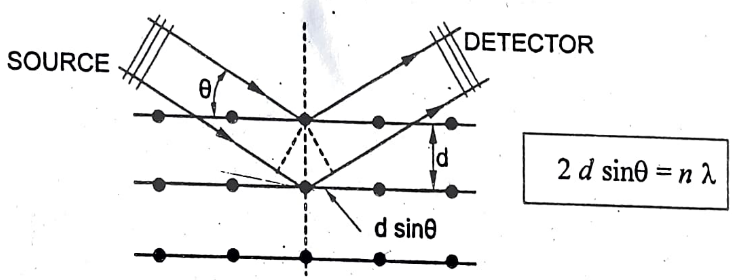


Fig. 4.8. Bragg's law

Pattern:

Fresnel's diffraction

Fraunhofer diffraction

common methods.

Electron diffraction

Neutron diffraction

X-ray diffraction

factors affecting intensity.

structure factor.

polarization factor.

Lorentz factor.

Advantage:

Data generation

Testing is cheap.

Limitation:

Sample prepartion is complex.

Source is costlier.

Application

Diffraction methods offers a unique way to measure micro stresses in crystalline materials, because each phase coll have its own diffraction pattern giving information on the stresses in the phase.

8. Spectroscopy technique.

- Spectrum.
- Spectroscopy:

Deals with the production, measurement and interpretation of spectra arising from the interaction of electromagnetic radiation with matter.

- Spectrometry:

It is the measurement of these spectrum responses and an instrument.

- Electromagnetic spectrum

Radio waves commercial radio, television microwave infrared radiation, visible light, UV light, X-rays and gamma rays.

Application:

Understanding constitution of matter from atoms to complex molecules.

Studies on environmental sample.

Mineralogy.

Advantage:

Non-destructive elemental analysis.

Need low working temperature.

UNIT-V

OTHER TESTING.

1, Overview: materials testing measurement of characteristics and behaviour of such.
2, Thermal analysis

Thermal properties:

Thermal testing is a form of analys tical Thermogravimetric Analysis science when Differential scanning calorimetry changes power compensation DSC in the properties material components are examined with respect to working and temperature.

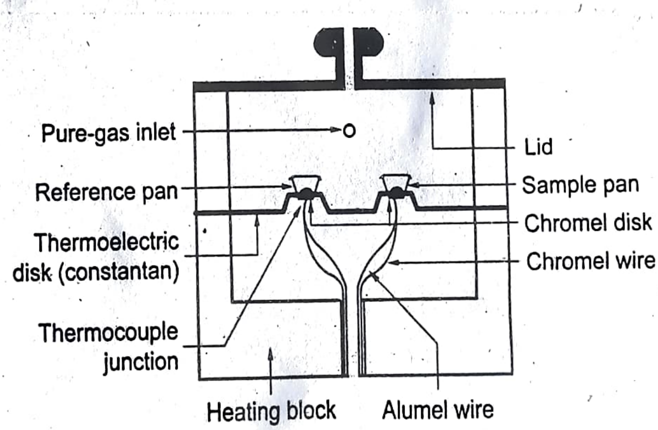


Fig. 5.2. Typical arrangement of heat flux DSC

Heat flux dsc. It is a group of techn of
in component which changes of physical or
chemical one block for both sample and
against physical ortime reference cells.

* working.
* DSC measure.
* DSC curve.

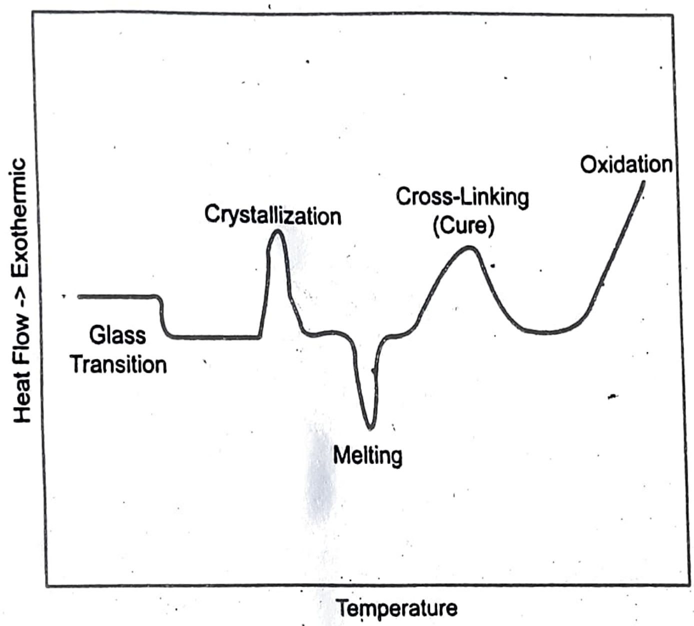


Fig. 5.3. DSC Curve

* Applications.
* Sources of errors ← Sample holder, sensor, Reference pan.
* Advantage.
* Disadvantage.

Dilatometer, Latent heat of fusion of materials. Latent heat vaporization of materials.

Q. Differential Thermal analysis.
principle.

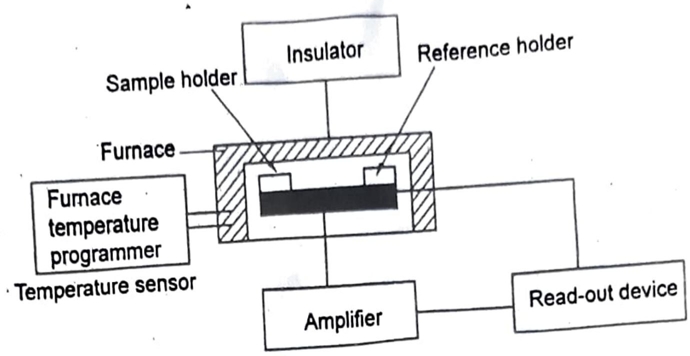


Fig. 5.4. Cross section of DTA

working of materials decide how it
read DTA curve. The major thermal properties

4. DTA Curve

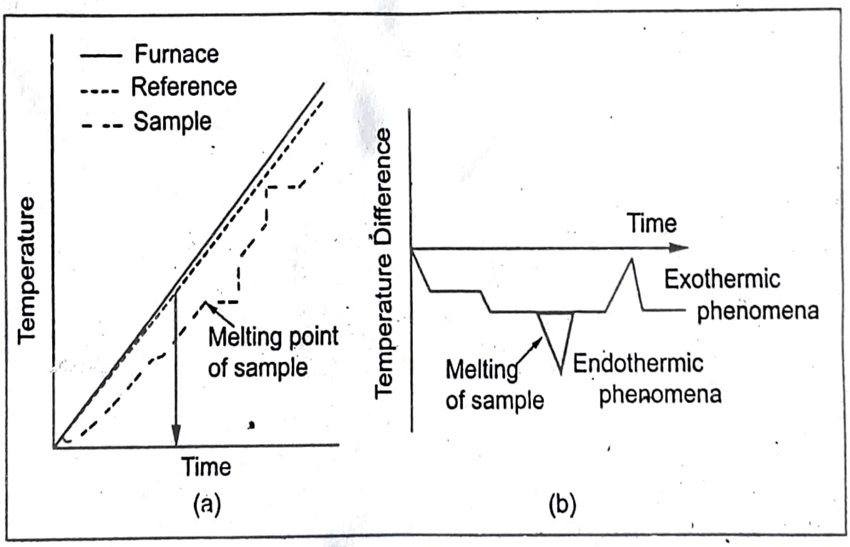


Fig. 5.5. (a) The DTA curve or thermo gram is a plot between differential temperature and Time. (b) DTA curve may be endothermic (downward plot) or exothermic (upward plot).

Factors affecting ...
Advantage product at the extremes of its
disadvantage intended gaseous atmosphere
or vaccum with measuring case temperature

3. Thermo- mechanical analysis.

principle of this the deformation of the the components. deformation temperature of probes on different loading under the construction of the sample displacement as Application function of temperature.

4. Thermo mechanical dynamic analysis

principle of this a otherwise known as the Types of dynamic applied where a small modes deformation is applied to a sample component in a cyclic manner. This allow working to the material. The term is also refers to analyzers that perform the test.

5. Chemical analysis

* properties
* testing
* Purpose.
* Techniques.
* X-ray fluroscence.
* Types.
* components.
* working
* applications.

⑥ Elemental analysis by inductively coupled plasma.

* methods of elemental analysis.

* Exciting source of mass and emission spectrometry

The Plasma discharges also uses RF power the Advantage of this the power supply like types of plasma like capacitively coupled & Inductive coupled plasma discharge the production of this is low background emission and relatively low chem. interfers

1. PRODUCTION OF PLASMA

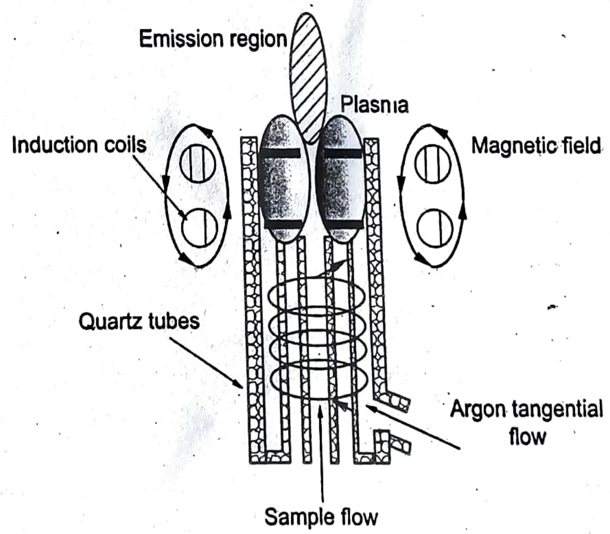


Fig. 5.9. Production process of plasma

* Characteristics of plasma.
high temperature, high electron density, Appreciable degree of ioniza-tion ⑤.

9. optical emission spectroscopy:

Based on excitation source optical emission spectroscopy classification.

8 inductively coupled plasma, optical emission spectrometry. The principle of this principle is the inductively couped of the components elements. high frequency sample solutions

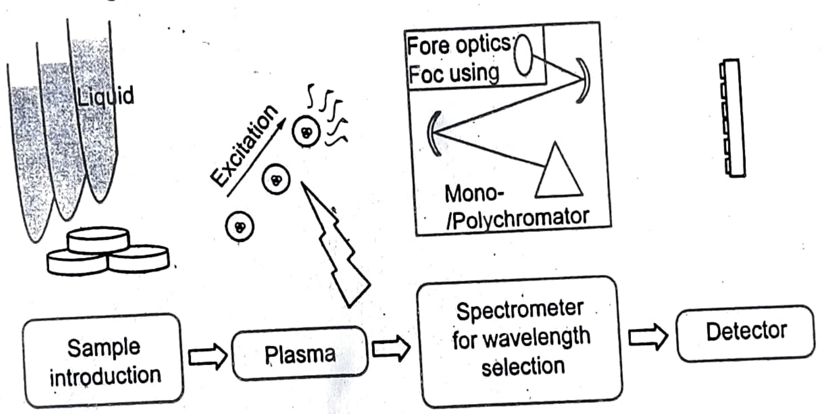


Fig. 5.10. Flow diagram of ICP-OES

* construction
* sample introduction
* production of emission.
* collection and detection of emission
  - Transfer
  - wavelength dispersive devices.

The detectors require for the solution to signal processing & instrument be pumped into the neubulizer control, the pump computer processing exclusively the choice working for ICP-OES applications

* Advantage.
* disadvantage
* Applications
  - Forensic analysis
  - Boron & Lithia in glass

8, Inductively coupled plasma mass spectrometery.

Inductively coupled plasma spectro-metry is an indusumental analytical based on the use of a high temperature ICP coupled to a mass spectometer.

principle:

The type of mass spectrometer that uses an inductively coupled plasma to ionize the sample. It atomize the sample and create atomic and small polyatomic component :

* peristaltic pump.
* Nebulizer & spray chamber
* Torch.
* plasma ionization source.
* Interface Region

Working.

The sample solution is introduced into the device by means of a peristaltic pump. There is becomes nebulized in a spray chamber.

Inside the plasma torch, solution

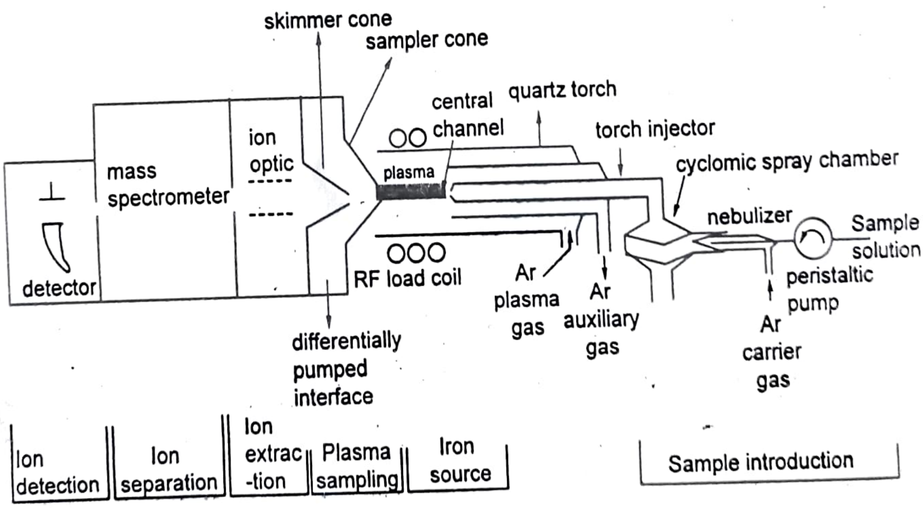


Fig. 5.12. Working flow of ICP-MS

Maintenance of ICP-MS.

pump tubing has the tendency to stack, which changes the amount of

Advantage:

Quantitative analysis is the fundam-ental tool used to determine analyte concentration in unknown sample.

Application:

- Simple metal analysis during metal based drug development.
- Impurity limit test.
- For elemental speciation

Disadvantage:

The high capital cost of the instrumentation

Lower precision compared with atomic absorption spectrometry.

9, Production of Emission:

Torches.

It consist a ring shaped toroidal plasma is formed, where the sample aerosol passes centrally through the hot plasma.

Radio frequency:

Radio frequency generator is the device that provides the power for the generator.

* Transfer optics.

The emission radiation from the region of the plasma known as the normal analytical zone is sampled for the spectrometric measurement.

* wavelength dispersive devices:

The next step in ICP-OES is the differentiation of the emission done by.

- diffraction grating
- prism.
- filters.

* Detectors:

Once the proper emission line has been isolated by the spectometer the dector, and its associated electronics