MT

Home Assignment - 1

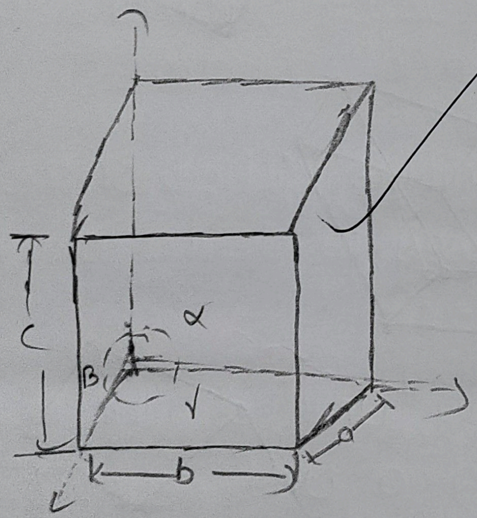
21000700042

① Discuss about i) Crystal systems and ii) Bravais lattices with neat sketches.

→ i) Crystal systems:-

Crystal system is a method of classifying crystalline substances on the basis of their unit cell. There are seven unique crystal systems (by assigning different values to lattice parameters).

Unit cell:- Smallest repetitive volume which contains the complete lattice pattern of a crystal.



7 crystal systems of varying symmetry are known. These systems are built by changing the lattice parameters. a, b and c are the edge lengths

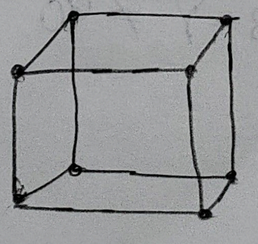
α, β and γ are interaxial angles.

The many thousands of lattices classified into seven crystal systems.

1. Cubic

$a = b = c$

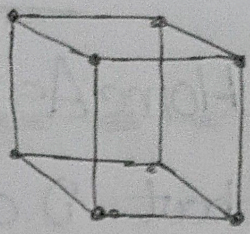
$\alpha = \beta = \gamma = 90^\circ$



2. Tetragonal

$a = b \neq c$

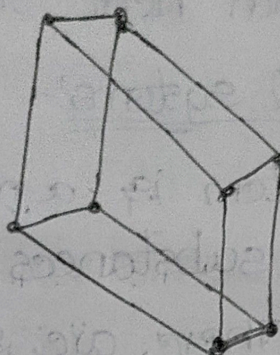
$\alpha = \beta = \gamma = 90^\circ$



3. Orthorhombic

$a \neq b \neq c$

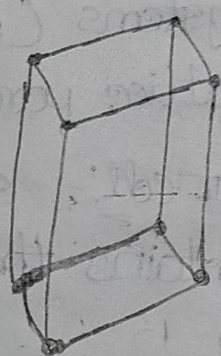
$\alpha = \beta = \gamma = 90^\circ$



4. Hexagonal

$a = b \neq c$

$\alpha = \beta = 90^\circ, \gamma = 120^\circ$

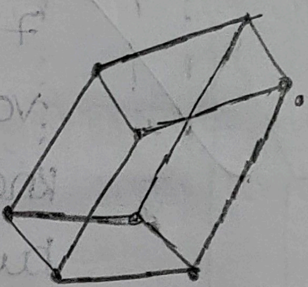


5. Monoclinic

$a \neq b \neq c$

$\alpha = \gamma = 90^\circ$

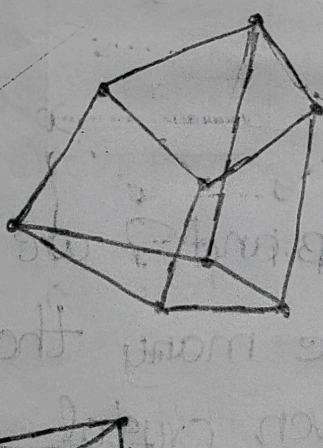
$\beta = 120^\circ$



6. Triclinic

$a \neq b \neq c$

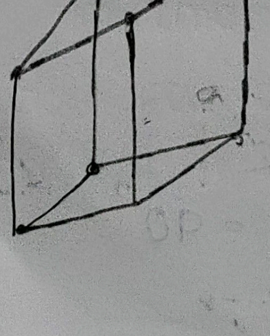
$\alpha \neq \beta \neq \gamma \neq 90^\circ$



7. Trigonal

$a = b = c$

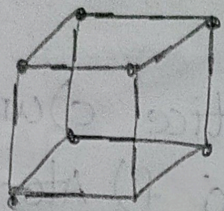
$\alpha = \beta = \gamma \neq 90^\circ$



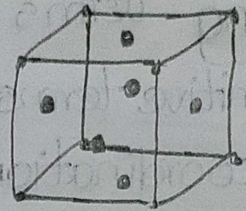
ii) Bravais lattice:-

A space lattice is an infinite, three dimensional array of points in which every point has surroundings identical with that of every other point.

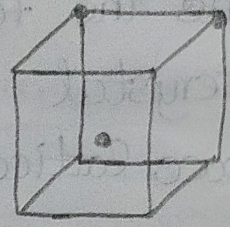
Lattice points can be arranged in only 14 different arrays called Bravais lattices.



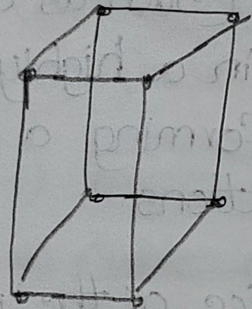
simple cubic



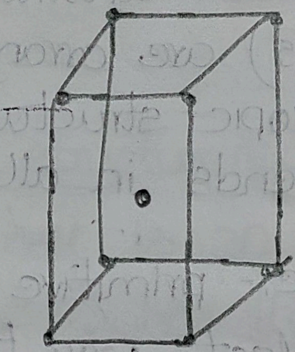
Face-centered cubic



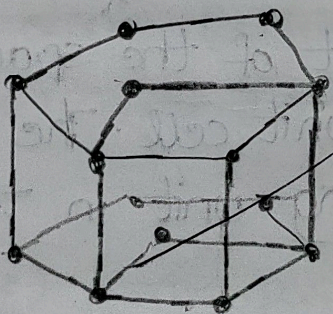
Body-centered cubic



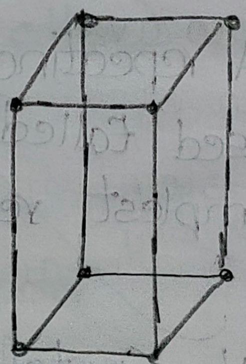
simple Tetragonal



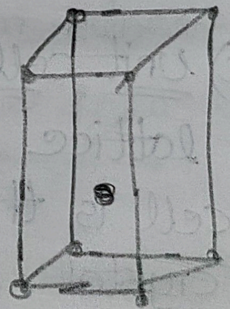
Body centered Tetragonal



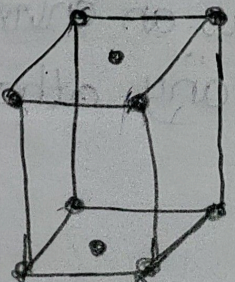
Hexagonal



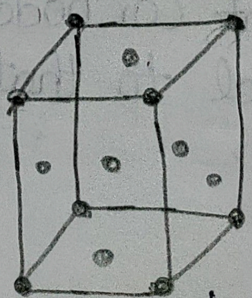
simple orthorombic



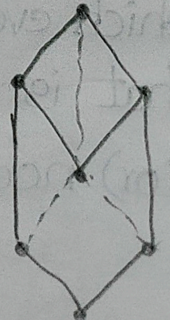
Body-centered orthorhombic



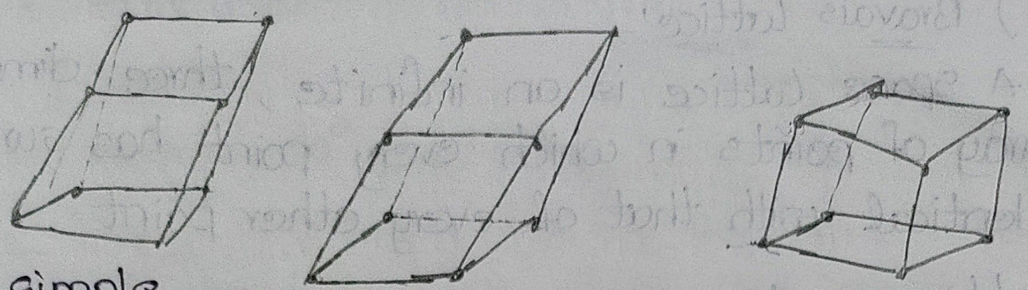
Base-centered orthorombic



Face-centered orthorombic



Rhombo-hedral



simple monoclinic | Base-centered monoclinic | Triclinic

② define the fallowing terms:

ⓐ crystal b) primitive terms lattice c) unit cell d) space lattice e) coordination nó f) Atomic packing factor.

Ans:- a) crystal:- A crystal (or) crystalline solid is a solid material whose constituents (such as atoms, molecules or ions) are arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions.

b) primitive lattice:- primitive lattice or the primitive cell is the smallest way to define a crystal cell (or) lattice.

c) Unit cell:- A repeating unit of the space lattice is used called a unit cell. The unit cell is the simplest repeating unit in the crystal.

d) space lattice:- Crystal (space) lattice is an imaginative grid system in three dimensions in which every point (or node) has an environment that is identical to that of any other point (or) node.

e) **Coordination number**:- The co-ordination number of an atom in a given molecule or a crystal refers to the total no. of atoms, ions (or) molecules bonded to the atom we are referring to.

f) **Atomic packing factor**:- The fraction of volume of the unit cell that is occupied by the "hard spheres".

$$APF = \frac{\text{volume of atoms in unit cell}^*}{\text{volume of unit cell}}$$

*) assume hard spheres.

(3) With a neat sketch explain the characteristics of i) SC ii) BCC iii) FCC iv) HCP.

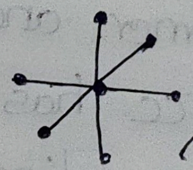
Ans:- i) **Simple cubic structure (SC)**:-

*) Cubic unit cell is 3D repeat unit.

*) Rare (only P_o has this structure)

*) close packed directions (directions along which atoms touch each other) are cube edges.

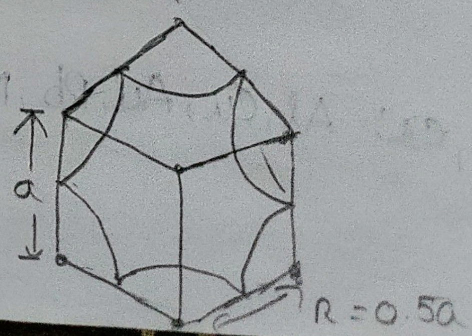
*) Coordination number = 6



*) Atomic packing factor $= \dfrac{\overset{\text{atoms/unit cell}}{(1)}\overset{\text{volume/atom}}{\left(\frac{4}{3}\pi(0.5a)^3\right)}}{\underset{\text{vol/unit cell}}{a^3}}$

= 0.52

*) Relation : R = 0.5a



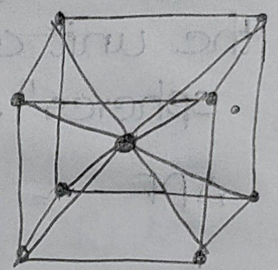
ii) Body Centered Cubic Structure (BCC)

*) The Body-centered Cubic (BCC) unit cell can be imagined as a cube with an atom on each corner, and an atom in the cube's centre.

*) BCC has 2 atoms per unit cell.

*) Coordination number = 8

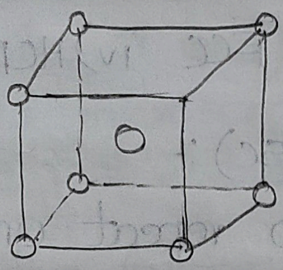
*) Relation : $R = \frac{\sqrt{3}}{4} a$



*) Atomic packing factor

$$= \frac{(2)\left[\frac{4}{3}\pi\left(\frac{\sqrt{3}a}{4}\right)^3\right]}{a^3} = 0.68$$

*) Ex:- Alpha-iron, Mo, K, Na, Ta, W, Va etc..



iii) Face-Centered Cubic Structure (FCC)

*) The Face-Centered Cubic (FCC) unit cell can be imagined as a cube with an atom on each corner, and an atom, on each face.

*) FCC has 4 atoms per Unit cell.

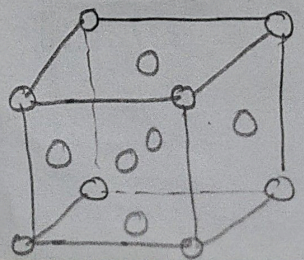
*) Co-ordination number = 12

*) Relation: $R = \frac{\sqrt{2}}{4} a$

*) Atomic packing factor $= \frac{(4)\left[\frac{4}{3}\pi\left(\sqrt{2}a/4\right)^3\right]}{a^3}$

$= 0.74$

ex:- Al, Cu, Au, Pb, Ni, Pt, Ag etc..



iv) Hexagonal close packed structure (HCP)

*) The Hexagonal close - Packed (HCP) unit cell can be imagined as a hexagonal prism with an atom on each vertex, and 3 atoms in the centre.

*) HCP has 6 atoms per unit cell.

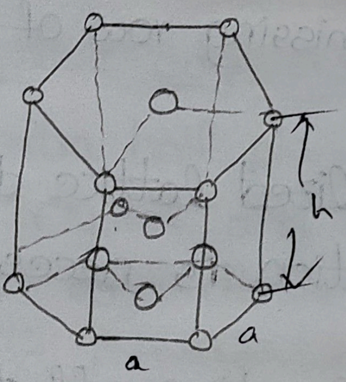
*) Coordination number = 12

*) Relation : $R = a/2$.

*) Atomic packing factor = $\dfrac{(6)\left(\frac{4}{3}\pi(0.5r)^3\right)}{24\sqrt{2}^{\,3}}$

$= 0.74$

Ex: Sc, Ti, Co, Zn etc....



(4) Explain the following defects with relevant examples.

a) point defects b) Dislocations c) surface defects

Ans: a) point defects:-

point defects are also called as zero dimensional defect. Point defects can be classified into various examples.

1) vacanies:

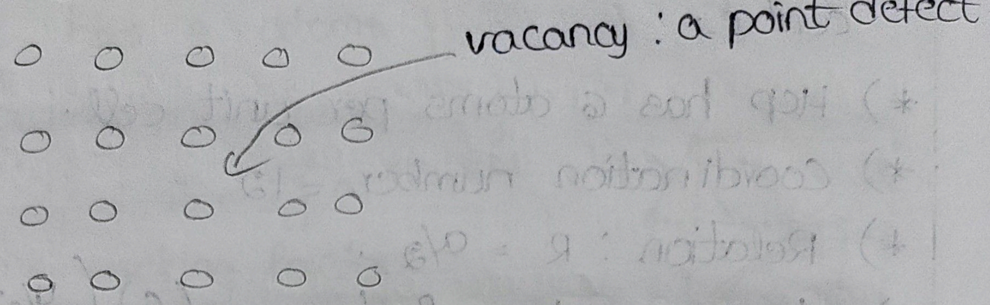
- Schottky defect
- Frenkel defect.

2) Interstitialcy:-

- self Interstitialcy

- Interstitialcy by foreign atom.

3) Impurities
- Substitutional impurity
- Interstitial impurity



b) Line defect Dislocation:-

*) Dislocation is a line defect.

*) A part of the line of atoms miss from its regular site and this missing row of atoms is called as dislocation.

*) Dislocation is a localized lattice disturbance.

*) Movement of dislocation is necessary for plastic deformation.

*) The behaviour of dislocation affect many properties of engineering materials.

*) Line defects are also called 1 dimensional defects. They can be classified into:

a) Edge dislocation
b) Screw dislocation
c) Mixed dislocation.

c) Surface defects:-

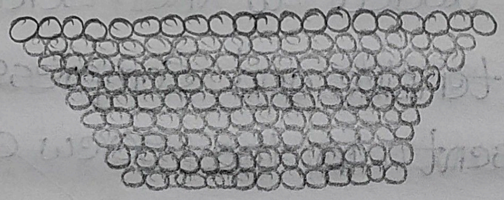
Surface defects can also be called 2-dimensional defects. These are areas of distortions that lie about a surface, having a thickness of a few atomic diameters (that is, the thickness is almost diameters negligible compared to other two dimensions of the surface).

*) Surface defects can be mainly classified into the following types:

- Grain boundary
- Twin boundary
- stacking fault
- Tilt boundary & Twist boundary.

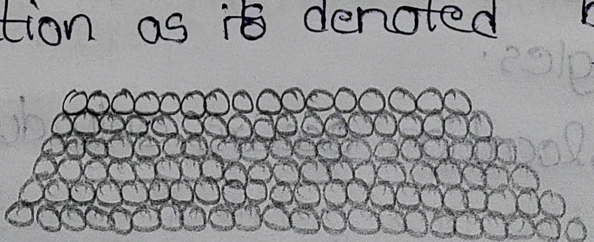
(5) Give the difference between
a) positive and Negative edge dislocation.

Ans:- → positive edge dislocation:-
The extra half plane is above the slip plane of the crystal and this dislocation is called positive edge dislocation and is denoted by inverse T.



($\perp$ → +ve)

Negative edge dislocation:-
The extra half plane is above the slip plane of the crystal and it is called negative edge dislocation as its denoted by T.



(T → -ve)

b) Edge and screw dislocation
edge dislocation:- *) edge dislocation occurs

due to the introduction or elimination of an extra row of atoms.

*) Shear, Tensile and compressive stress fields may be present in the edge dislocation.

*) In this dislocation, Burger's vector always perpendicular to the dislocation line.

*) Region of lattice extends along an edge inside a crystal.

*) This dislocation occurs due to climb and glide motion.

*) There are two types of edge dislocation, positive and negative.

Screw dislocation:-

*) Screw dislocation provides easy crystal growth because of additional unit cells and atoms can be added to the screw.

*) Shear, tensile and compressive stress fields, are absent in the screw dislocation.

*) In this dislocation, Burger's vector always parallel to the dislocation line.

*) Region of lattice disturbance is in two seperate planes and cross each other at right angles.

*) This dislocation occurs only due to glide motion.

*) Screw dislocation does not show any type like edge dislocation.

*) Tilt and Twist boundary -

c) Tilt and Twist boundary

→ Tilt boundaries:-

Tilt boundary or low angle boundaries are boundaries between adjacent crystals of same structure but with small difference in crystal orientations, and might be considered to have an array of parallel dislocations.

Tilt boundaries are boundaries between adjacent grains having misorientation in such a way that the lattices appear to be rotated. (twisted) with respected to one another.

① Grain and Twin boundary:-

The grain boundary can occur between any type of crystal gains.

This defected tends to decrease the electrical and thermal conductivity of the material.

Grain boundaries tend to disrupt the motion of dislocations through the material, there by reducing the crystalline size, which leads to improving the mechanical strength.

Twin boundary

*) The twin - boundary can occur between only the crystals having same lattice structure

*) Twin boundary is the interface between

two separate crystals that are mirror images of each other.

*) Twin boundary occur due to the formation of walls of mismatch dislocations during the dislocation movement process.

⑥ List out various differences between destructive and non-destructive testing methods:-

Destructive Testing	Non-Destructive Testing
*) Tested specimens get deformed (or) damaged during the testing process.	*) Tested specimen does not get damaged during the testing process.
*) Destructive testing is done to identify the chemical and physical properties of the tested items.	*) Non destructive testing is carried out to find defects in the material.
*) DT is extremely useful for design purposes.	*) NDT is great for spotting early deterioration signs of working equipment.
*) The tested item cannot be used for its intended purpose.	*) The item can be used in normal operation after testing - if it is found not to be defective.
*) Destructive testing is more expensive and time consuming.	*) NDT is quick and easy even though certain testing

	equipment can be fairly expensive.
*) Examples: bending Test, Tensile test, hardness test, corrosion testing, compression testing.	*) Ex: ultrasonic testing, radiography testing vibration analysis, magnetic particle testing.

(7) Explain the following NDT Techniques with a neat sketch. Also find out various applications, advantages and disadvantages.

Ans: i) Dye penetrant test.

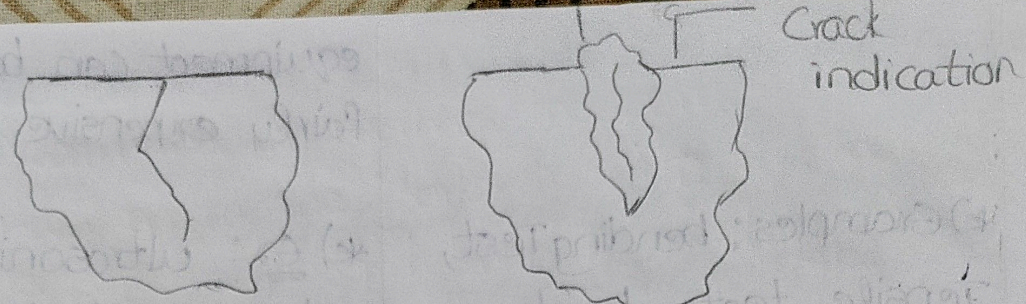
-) In penetrant testing, a liquid with high surface wetting characteristics is applied to the surface of a component under test.

*) the penetrant "penetrates" into surface breaking discontinuities via capillary action and other mechanisms.

*) Excess penetrant is removed from the surface and a developer is applied to pull trapped penetrant back the surface.

*) with good inspection technique, visual indication of any discontinuities present become apparent

*) PT increases the "seeability" of small discontinuities that the human eye might not be able to detect alone.



Applications:-

*) The penetrant is then applied to the surface of the item being tested. The penetrant is allowed "dwell time" to soak into any flaws (generally 5 to 30 min).

*) The dwell time mainly depends upon the penetrant being used, material being tested and the size of flaws sought.

*) Smaller flaws require a longer penetration time.

Advantages:-

1) Relative ease of use.
2) Can be used on a wide range of material types
3) Large areas can be inspected rapidly and at low cost.
4) parts with complex geometries are inspected.
5) Initial equipment investment is low.
6) Equipment very portable.

Disadvantages:-

*) only defects surface breaking defects.
*) Requires relatively smooth nonporous material.
*) precleaning is critical. Contaminants can mask defects.

*) Requires multiple operations under controlled conditions.

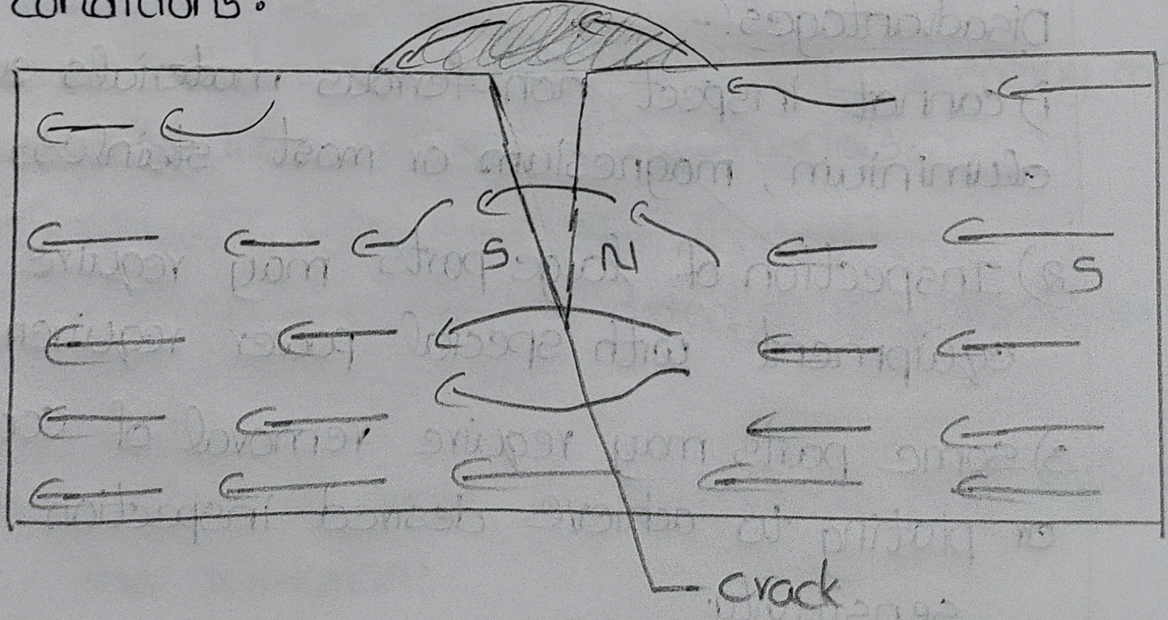
*) chemical handling precautions necessary (toxicity, waste, fire).

*) post cleaning is necessary to remove chemicals.

ii) <u>Magnetic particle test</u>

A ferromagnetic test specimen is magnetized with a strong magnetic field created by a magnet (or) special equipment. If the specimen has a discontinuity, the discontinuity will interrupt the magnetic field flowing through the specimen and a leakage field will occur.

*) ~~Fille~~ Finely milled iron particles coated with a dye pigment are applied to the test specimen. These particles are attracted to leakage fields and will cluster to form an indication directly over the discontinuity. This indication can be visually detected under proper lighting conditions.



Applications:-

*) with the dry method, the particles are lightly dusted on to the surface. with the wet method, the part is flooded with a solution carrying the particles.

*) The dry method is more portable. The wet method is generally more sensitive since the liquid carrier gives the magnetic particles additional mobility.

Advantages:-

1) can detect both surface and near sub-surface defects.
2) can inspect parts with irregular shapes easily.
3) precleaning of components is not as critical as it is for some other inspection methods.
4) Fast method of inspection and indications are visible directly on the specimen surface.
5) Considered low cost.

Disadvantages:-

1) cannot inspect non-ferrous materials such as aluminium, magnesium or most stainless steels.
2) Inspection of large parts may require use of equipment with special power requirements.
3) some parts may require removal of coating or plating to achieve desired inspection sensitivity.
4) Limited sub surface discontinuity detection capabilities

iii) ultrasonic Test:-

—) ultrasonic testing uses high frequency sound energy to conduct examinations and make measurements.

*) ultrasonic examinations can be conducted on a wide variety of material forms including castings, forgings, welds and composites.

*) Sound waves travel through materials by vibrating the materials (or) particles that make up the materials.

*) The ultrasonic of the sound with a pitch too high to be defected by the human ear.

*) The pitch of the sound is determined by the frequency of the wave.

*) ultrasonic waves can be reflected, refracted and focused.

*) Reflection and refraction occurs when sound waves interact with interfaces of differing acoustic properties.

*) In solid materials, the vibrational energy can be split into different wave models.

*) ultrasonic reflections from the presence of discontinuities enables detection and location.

Advantages:-

*) sensitive to small discontinuties both surfaces and subsurface.

*) Depth of penetration for flow detection (or)

measurement is superior

*) only single-sided access is needed when Pulsecho technique is used.

*) High accuracy in determining reflector position and estimating size and shape.

*) Electronic equipment provides instantaneous results.

Disadvantages:-

*) surface must be accessible to transmit ultrasound.

*) skill and training is more extensive than with some other methods.

*) Normally requires a coupling medium to promote transfer to sound energy into test specimen.

*) Materials are rough, irregular in shape, very small, expectionally thin (or) not homogeneous are difficult to inspect.

*) Cast iron and other coarse grained materials are difficult to inspect due to low sound transmission and high signal noise.

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