1.1.1. What is NDT?

- ✓ *NDT* stands for *N*on-*D*estructive *T*esting.
- ✓ As its name implies, *non-destructive testing means testing of materials without destroying them.*
- ✓ A non-destructive test is an examination of an object which will not produce any kind of damage or destruction to the sample.
- ✓ ***Definitions:*** Some of the commonly used definitions of NDT are given below:

(i)	***Non-destructive testing is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system.*** In other words, when the inspection or test is completed, the part can still be used.
(ii)	***"NDT is an examination that is performed on an object of any type, size, shape or material to determine the presence or absence of discontinuities, or to evaluate other material characteristics".***

(iii) *NDT is a procedure which covers the inspection and/or testing of any material, component or assembly by means which do not affect its ultimate serviceability.*
(iv) *NDT is the examination of an object with the technology that does not affect the object's future usefulness.*
(v) *NDT means the use of non-invasive techniques i) to determine the integrity of a material, component or structure, or ii) to qualitatively measure some characteristics of an object.*
(vi) *NDT refers to technology that allows a component to be inspected for serviceability, without impairing its usefulness.*

- ✓ The other terms commonly used for NDT are ***Non-Destructive Evaluation (NDE)*** and ***Non-Destructive Inspection (NDI).***
- ✓ The NDT methods are becoming popular because these can be carried out without damaging the parts in use.

1.1.2. Objectives of NDT

- ✓ NDT can have several objectives which includes:

  - Materials sorting;
  - Materials characterization;
  - Property monitoring (for process control);
  - Thickness measurement;
  - Defect detection/location; and
  - Defect characterization.

- ✓ However the major task of NDT is to detect and identify the range of defects. Defects can include production flaws such as heat treatment cracks, grinding cracks, inclusions (of many types), voids (pores), and fatigue cracks (generated during service).

1.1.3. Uses of NDT methods

The NDT methods are most commonly used to achieve the following purposes:

1. Flaw detection and evaluation.
2. Leak detection.
3. Location measurement.
4. Dimensional measurements.
5. Structure and microstructure characterisation.
6. Estimation of mechanical and physical properties.
7. Stress-strain and dynamic response measurement.
8. Material sorting.
9. Chemical composition determination.

In this unit, the basic concepts of NDT, and overview of various NDT methods will be discussed in detail.

✓ ***Non-destructive testing methods:*** There are number of NDT methods are being employed in practice. Some of the most commonly used NDT methods are:

1. Visual inspection	2. Liquid penetrant testing
3. Magnetic particle testing	4. Thermography
5. Eddy current testing	6. Ultrasonic testing
7. Acoustic emission testing	8. Radiographic testing
9. Laser testing	10. Leak testing

1.5.1. Visual Inspection

1.5.1.1. What is it?

- ✓ Visual inspection is the simplest, fastest, and most widely used non-destructive testing method.
- ✓ *Visual inspection is carried out with the naked eye (unaided) or using some optical aids (aided) such as mirrors, magnifying glasses, and microscopes.*

- ✓ ***Definition:*** *Visual Inspection is commonly defined as "the examination of a material, component, or product for conditions of non-conformance using light and the eyes, alone or in conjunction with various aids".*
- ✓ Visual inspection often also involves shaking, listening, feeling, and sometimes even smelling the component being inspected.
- ✓ *Visual inspection is commonly employed to support/ compliment other NDT methods.*
- ✓ Digital detectors and computer technology have made it possible to automate some visual inspections. This is known as ***machine vision inspection.***

1.5.1.2. Characteristic Detected (Applicability)

The visual inspection is commonly used:

(i) To detect surface characteristics such as finish, scratches, cracks or color.

(ii) To check stain in transparent materials.

(iii) To inspect corrosion.

1.5.1.3. Principle

- ✓ Seeing is believing and the art of seeing is the visual inspection technique.
- ✓ Visual testing requires adequate illumination of the test surface and proper eye-sight of the tester.
- ✓ The test specimen is illuminated and the test surface is observed and examined. Wherever required, the optical aids such as mirrors, magnifying glasses, microscopes, video cameras and computer-vision systems can be employed.

1.5.1.4. Advantages

Some of the advantages of visual testing are as follows:

(i) Simple and easy to use.

(ii) Relatively inexpensive.

(iii) Testing speed is high.

(iv) Testing can be performed on components which are in-service.

(v) Permanent records are available when latest equipment is used.

1.5.1.5. Limitations

Some of the limitations of visual testing are as follows:

(i) The test results depend on skill and knowledge of tester.

(ii) Limited to detection of surface flaws.

(iii) Eye resolution is weak.

(iv) Eye fatigue.

1.5.1.6. Applications

Typical applications of visual inspection include:

(i) Checking of the surface condition of the component.

(ii) Checking of alignment of muting surfaces.

(iii) Checking of shape of the component.

(iv) Checking for evidence of leaking.

(v) Checking for internal side defects.

1.5.2. Liquid Penetrant Testing

1.5.2.1. What is it?

- ✓ Liquid penetrant method is an effective method of detecting surface defects in metals and other non-porous material surfaces.
- ✓ It detects flaws that are open to the surface e.g., cracks, seams, laps, lack of bond, porosity, cold shut etc.
- ✓ It can be effectively used for the inspection of :
  - i) ferrous metals,
  - ii) non-ferrous metals, and
  - iii) non-porous, non-metallic materials such as ceramics, plastics and glass.
- ✓ This method is widely used for testing of non-magnetic materials.

1.5.2.2. Characteristics Detected (Applicability)

Liquid penetrant testing is widely used:

(i) To locate cracks, porosity, and other defects that breaks the surface as a material and has enough volume to trap and hold the penetrant material.

(ii) To inspect large areas very efficiently and will work on most non-porous materials.

1.5.2.3. Principle

- ✓ *The principle of liquid penetrant tests is that the liquid penetrants are drawn into surface flaws such as cracks or porosities by capillary action. Then the developer material in conjunction with visual inspection reveals the surface flaw.*
- ✓ In this testing, 'penetrant' and 'developer' are used.
  - ***Penetrant*** is a liquid capable of testing the entire surface and being drawn into the openings. Usually brightly coloured dyes or fluorescent materials are used as penetrants.
  - ***Developer*** is an absorbent material capable of drawing traces of penetrants from the defects back onto the surface.
- ✓ Fig. 1.10 illustrates a typical sequence of operations for liquid-penetrant inspection to detect the presence of surface flaw in a workpiece.

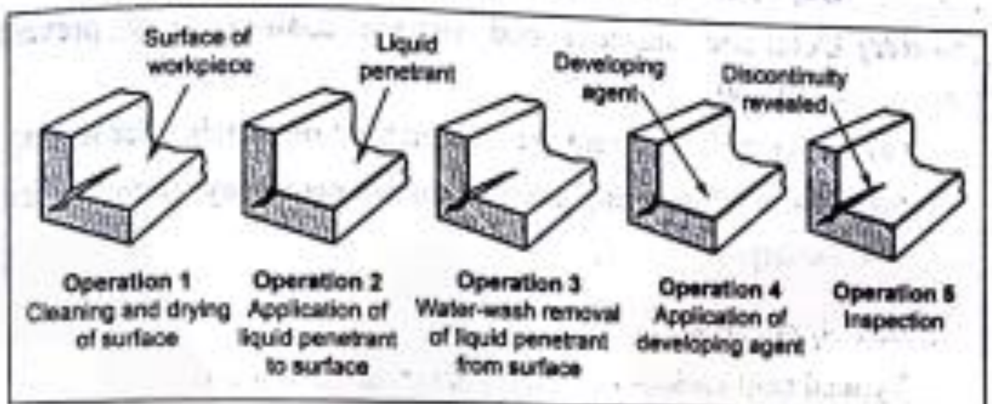


Fig. 1.10. Sequence of operations for liquid penetrant inspection to detect the presence of cracks and other flaws in a workpiece

1.5.2.4. Advantages

Some of the advantages of liquid penetrant testing are as follows:

(i) Sample and easy to use.

(ii) Inexpensive and versatile.

(iii) Highly portable.

(iv) Highly sensitive to fine, tight discontinuities.

(v) Applicable to variety of materials.

(vi) Applicable to complex shapes.

(vii) Large surface areas or large volumes of parts/materials can be inspected rapidly and at low cost.

1.5.2.5. Limitations

Some of the limitations of liquid penetrant testing are as follows:

(i) It can only detect flaws that are open to the surface.

(ii) It cannot be used on porous and very rough surfaces.

(iii) Surface preparation (before testing) is critical as contaminants can mask defects. So test surface must be free of all dirt, oil, grease, paint, rust, etc.

(iv) Deformed surfaces and surface coatings may prevent detection.

(v) It is required to remove all penetrant materials after testing.

(vi) Chemical handling precautions are necessary (toxicity, fire, waste).

1.5.2.6. Applications

Typical applications of liquid penetrant testing are:

(i) Inspection of tools and dies.

(ii) Inspection of tanks, vessels, reactors, piping, dyers, and pumps in the chemical, petrochemical, food, paper, and processing industries.

(iii) Inspection of diesel locomotive, truck, and automobile parts (such as axles, wheels, gears, crankshaft, cylinder blocks, connecting rods, cylinders, transmissions, and frames).

(iv) Inspection of field drilling rigs, drill pipe, castings, and drilling equipment.

(v) Inspection of aircraft engine parts, propellers, wing fittings, castings and so on.

1.5.3. Magnetic Particle Testing

1.5.3.1. What is it?

- ✓ *Magnetic particle testing is used for the testing of materials which can be easily magnetized.*
- ✓ This method is capable of detecting surface and subsurface flaws such as cracks and inclusions.
- ✓ *This method can be used for testing of ferromagnetic materials (such as iron, steel, nickel, and cobalt alloys).* The nonferrous metals (such as aluminium, magnesium, copper, lead, tin, and titanium) and the ferrous (but not ferromagnetic) austenitic stainless steel cannot be inspected using this method.
- ✓ It is a relatively simple, inexpensive and rapid technique.
- ✓ It is free from any restrictions as to size, shape, composition, and heat treatment of a ferromagnetic specimen.

1.5.3.2. Characteristics Detected (Applicability)

The magnetic particle testing method is used extensively to detect surface and near surface cracks, voids, inclusions, or materials or geometry changes in ferromagnetic parts and materials.

1.5.3.3. Principle

- ✓ Fig. 1.11 illustrates the basic principle of magnetic particle testing method.
- ✓ Magnetic particle inspection is based on the principle that ferromagnetic materials, when magnetized, will have a distorted magnetic field in the vicinity of flaws and defects, as shown in Figs. 1.11(a) and (b).
- ✓ The flaws and defects are revealed by the application of minute magnetic particles (such as dry iron powder or iron powder in suspension as a liquid). The magnetic particles are strongly attracted to surface regions where the flux is concentrated.
- ✓ This would create a visual indication approximating the size and shape of the flaw (Fig. 1.11(c)). The parts have to the demagnetized and cleaned after inspection.

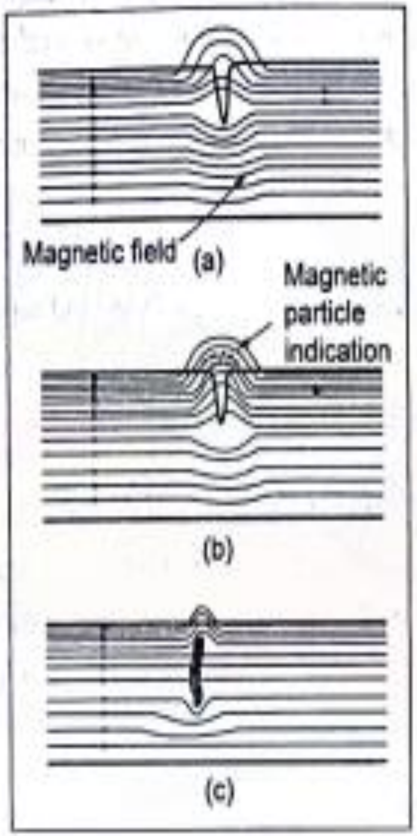


Fig. 1.11. (a) Magnetic field showing disruption by a surface crack; (b) Magnetic particles are applied and are preferentially attracted to field leakage; (c) Subsurface defects can also produce surface-detectable disruptions if they are sufficiently close to the surface

✓ Thus the three procedural steps involved (Fig. 1.11) are:

(a) Magnetizing the test specimen,

(b) Applying magnetic particles on the test specimen, and

(c) Locating the defects.

1.5.3.4. Advantages

Some of the advantages of magnetic particle testing are as follows:

(i) It is relatively simple and fast.

(ii) It can reveal both surface and subsurface flaws and inclusions.

(iii) It is portable.

(iv) Applicable to complex geometries.

(v) Applicable to any size of the component, as long as it can induce uniform magnetic fields within the piece.

1.5.3.5. Limitations

Some of the limitations of magnetic particle testing are as follows:

(i) Applicable only to ferromagnetic materials.

(ii) Alignment of the flaw and the field affects the sensitivity so that multiple inspections with different magnetizations may be required.

(iii) Can only detect defects at or near surfaces.

(iv) After testing, the part must be demagnetized and cleaned.

(v) High current source is required.

(vi) Paint or other nonmagnetic coverings adversely affects sensitivity.

1.5.3.6. Applications

Typical applications of the magnetic particle testing method include:

(i) Inspection of fans and blowers in thermal power plants.

(ii) Inspection of weld cracks.

(iii) Inspection of connecting rods.

(iv) Underwater inspections such as offshore structural welds, pipeline inspection and ship structures.

1.5.5. Eddy Current Testing

1.5.5.1. What is it?

- ✓ *Eddy Current Testing (ECT) is an electromagnetic non-destructive testing technique.*
- ✓ *This method can be used only on all electrically conducting materials.*
- ✓ The eddy current testing is also known as ***inductive testing.***

1.5.5.2. Characteristics Detected (Applicability)

This method is widely used to:

(i) To detect surface defects (seams, laps, cracks, voids and inclusion).

(ii) To sort dissimilar metals.

(iii) To measure or identify properties such as electrical conductivity, magnetic permeability, grain size, hardness, and physical dimensions.

(iv) To measure the thickness of a nonconductive coating on a conductive metal (or the thickness of a nonmagnetic metal coating on a magnetic metal).

(v) To measure case hardening depth.

1.5.5.3. Principle

- ✓ *The eddy current testing works on the basis of electromagnetic induction.*
- ✓ In this method, eddy currents are induced in a test object by bringing it close to on alternating current carrying coil Fig. 1.12(a). These eddy currents are normally parallel to the coil winding. The defects in the test object impede and change the direction of eddy currents and cause changes in the electromagnetic field. These changes affect the inspection coil, the voltage of which is monitored to determine the presence of defects.

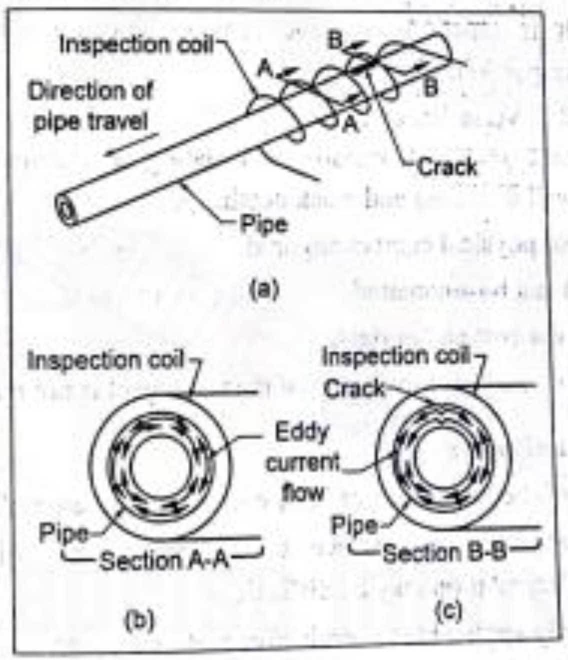


Fig. 1.12. Effects of a crack on the pattern of eddy current flow in a pipe

- ✓ Fig. 1.12(b) illustrates the effect of a crack on the pattern of eddy current flow in a pipe.

- The pipe travels along the length of the inspection coil as shown in Fig. 1.12(a).
- Fig. 1.12(b) shows section A-A which has no crack and hence the eddy current flow is symmetrical.
- Fig. 1.12(c) depicts section B-B, where a crack present and the eddy current flow is impeded and changed in direction.

1.5.5.4. Advantages

Some of the advantages of eddy current testing are as follows:

(i) It can detect both surface and near-surface irregulations.

(ii) It is quick to use and provides immediate results of inspection.

(iii) It is versatile, as it can detect flaws, variations in alloy or heat treatment, variations in plating or coating thickness, wall thickness and crack depth.

(iv) No physical contact required.

(v) It can be automated.

(vi) Low cost and portable.

(vii) Pre- and post-treatment of the test object is not required.

1.5.5.5. Limitations

Some of the limitations of eddy current testing are as follows:

(i) Response is sensitive to a number of variables, so interpretation may be difficult.

(ii) Only applicable to conductive materials, such as metals.

(iii) Reference standards are needed for comparison.

(iv) Highly skilled operators are required to perform inspection.

(v) It is not reliable on carbon steel for the detection of sub- surface flaws and also not suitable for large areas.

(vi) Its depth of penetration is limited to 8 mm.

(vii) Constant separation distance between coils and specimen is required for good results.

(viii) No permanent record.

1.5.5.6. *Applications*

Typical applications of eddy current testing include:

(i) Detection and measurement of flaws in steering mechanisms, airplane landing gears, engine parts, reactor and steam generator turbines, aircraft wheels, aircraft wing structures, condenser pipes, turbine blades, etc.

(ii) Detection and determination of the severity of various surface cracks, (stress, hardening, grinding, etc) weld seams, laps, pits, scabs, porosity, voids and inclusions.

(iii) Measurement of coating and plating thickness.

(iv) Detection and measurement of flaws in seamless, hot-rolled steel tubes; welded tubes; fastener holes, etc.

(v) Measurement of dimensional differences in machines, formed, or stamped parts.

(vi) Determination of the hardness and depth of case hardening in bearing rings and other parts.

(vii) Determination of the carbon content of various steels and alloy composition of ferromagnetic materials based on permeability.

1.5.6. Ultrasonic Testing

1.5.6.1. What is it?

- ✓ *Ultrasonic testing* is one of the popular non-destructive testing methods, that *uses the sound energy to determine the integrity of the test objects.*
- ✓ Even from early days, sound has been used to provide an indication of product quality. A cracked bell will not ring true, but a fine crystal goblet will have a clear ring when tapped lightly. This basic phenomenon is employed in ultrasonic testing.
- ✓ *In ultrasonic testing, the very short range, high frequency ultrasonic waves (whose range lies between 0.5–20 MHz) are used for detection of surface and sub-surface flaws in the test objects.*
- ✓ The ultrasonic waves are usually generated by the piezoelectric effect which converts electrical energy to mechanical energy. A quartz crystal is used for this purpose.

1.5.6.2. Characteristics Detected (Applicability)

The ultrasonic testing method is used:

(i) For detection of flaws in materials.

(ii) For measurement of thickness.

(iii) For the determination of mechanical properties and grain structure of materials.

1.5.6.3. Principle

- ✓ *In ultrasonic inspection, an ultrasonic beam travels through the test object. An internal defect, such as crack, interrupts the beam and reflects back a portion of the ultrasonic energy. The amplitude of the energy reflected, and the time required for return, indicate the presence and location of any flaws in the test object.*
- ✓ Fig. 1.13 illustrates as typical simple ultrasonic inspection of a flat plate.
  - The ultrasonic inspection employs sending separate probes namely transducer and receiving transducer, as shown in Fig. 1.13(a).
  - Fig. 1.13(b) depicts the plot of sound intensity or transducer voltage versus time showing the initial pulse and echoes from the bottom surface and intervening defect.

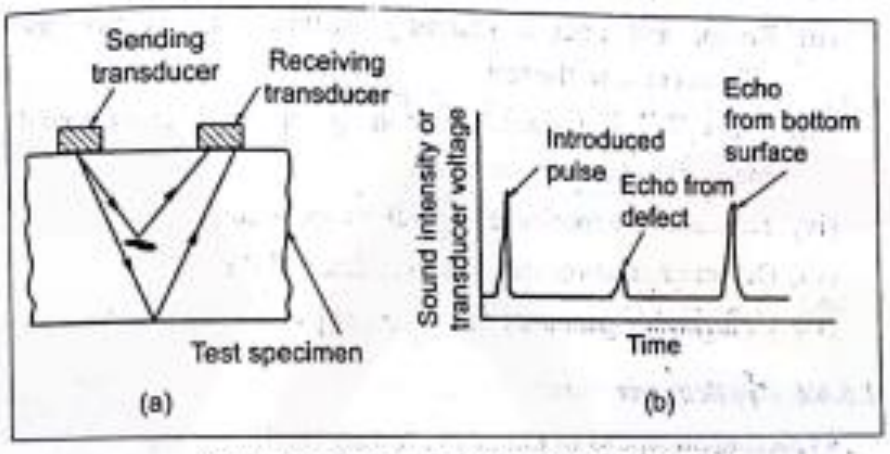


Fig. 1.13. Ultrasonic inspection of a flat plate

1.5.6.4. Advantages

Some of the advantages of ultrasonic testing are as follows:

(i) It can detect internal defects.

(ii) High sensitivity, greater accuracy than other methods in determination of internal defects.

(iii) High-speed test with immediate test results.

(iv) Portable device.

(v) It can be automated and recorded.

(vi) High penetration in most important materials (upto 60 ft in steel).

(vii) It indicates both flaw size and location.

(viii) It requires access to only one surface of the test object.

(ix) It presents no radiation or safely hazard.

(x) Repeatability of the ultrasonic testing is high.

1.5.6.5. Limitations

Some of the limitations of ultrasonic testing are as follows:

(i) Surface must be accessible to transmit ultrasound.

(ii) Rough and uneven scanning surfaces can reduce the effectiveness of the test.

(iii) A couplant is required to promote the transfer of sound energy into the test specimen.

(iv) Trained and experienced operators are required.

(v) Defect orientation affects defect detectability.

(vi) Unfavorable geometry of the test object causes problems.

1.5.6.6. *Applications*

Typical applications of ultrasonic testing method include.

(i) Inspection of large castings and forging, for internal soundness, before carrying out expensive machining operations.

(ii) Inspection of moving strip or plate for laminations as regards its thickness.

(iii) Routine inspection of locomotive axles and wheel pins for fatigue cracks.

(iv) Inspection of rails for bolt-hole breaks without dismantling rail-end assemblies.

1.5.8. Radiography Testing

1.5.8.1. What is it?

- ✓ Radiography testing is one of the most important, versatile and widely accepted of all the non-destructive examination methods.
- ✓ The radiographic testing method is commonly used for the detection of internal flaws such as cracks and porosity in many different materials and configuration.
- ✓ *In radiography testing, X-ray or gamma ray is used to determine the internal soundness of the metal; hence it is also called as X-ray or* ***gamma ray testing.***
- ✓ Radiographic inspection employs the same principles and techniques as those of medical *X*-rays.

1.5.8.2. Characteristics Detected (Applicability)

The radiography testing method is used:

(i) To inspect almost any material for surface and sub-surface defects.

(ii) To locate and measure internal features.

(iii) To confirm the location of hidden parts in an assembly.

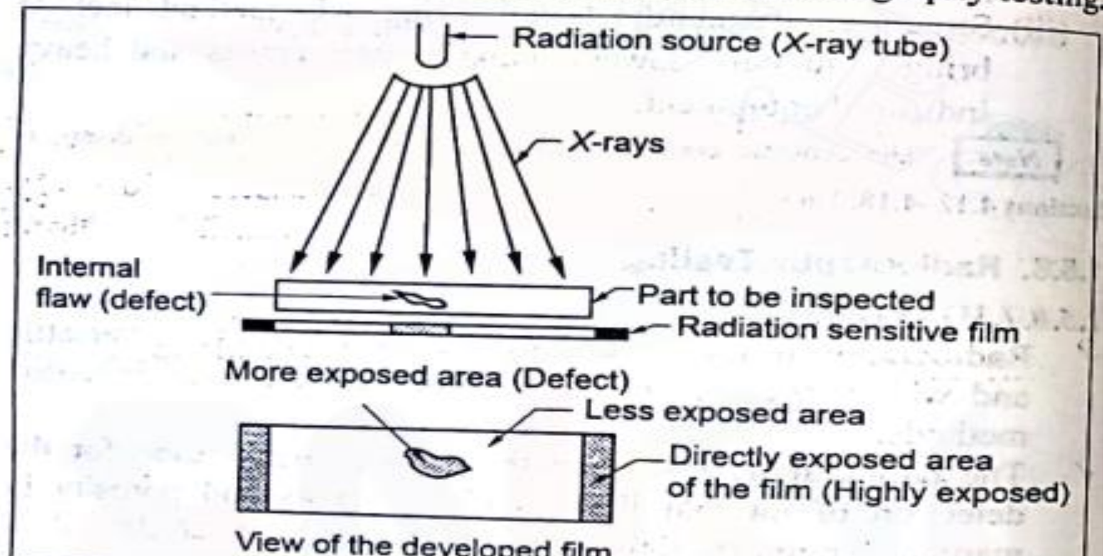
(iv) To measure the thickness of materials.

1.5.8.3. *Principle*

✓ Radiography uses an *X*-ray or gamma ray as a source c radiation which passes through the test object and is capture on film or digital device.

✓ After processing the film, an image of varying density i obtained. Using the image, possible imperfections an identified through density changes.

✓ Fig. 1.15 illustrates the basic principles of radiography testing.



1.5.8.4. *Advantages*

Some of the advantages of radiography testing method are as follows:

(i) Wide variety of materials can be inspected.

(ii) It can be used for checking internal malstructure, misassembly or misalignment.

(iii) Minimum surface preparation is required.

(iv) Sensitivity to changes in thickness, corrosion, voids and cracks.

(v) Both surface and subsurface defects can be detected.
(vi) Provides permanent record of inspection.
(vii) It can inspect complex shapes and multi-layered structures without disassembly.

1.5.8.5. Limitations

Some of the limitations of radiographic testing method are as follows:

(i) Most costly of the NDT methods (as it involves expensive equipment, film and processing).
(ii) Access to both sides of the specimen is required.
(iii) It cannot detect planar defects readily.
(iv) Orientation of the specimen is critical to assess the defects.
(v) Determination of flaw depth is impossible without additional angled exposures.
(vi) Extensive operator training and skill required.
(vii) Additional safety measures are essential to present radiation hazard for personnel.

1.5.8.6. Applications

Typical applications of radiography testing method include:

(i) Detection of internal discontinuities such as shrinkage, cracking and porosity in castings.
(ii) Verification of integrity of internal components.
(iii) Determination of the quality of welded sections and pipes.
(iv) Identification of the extent of corrosion.
(v) Inspection of variety of non-metallic parts.
(vi) Locating discontinuities in fabricated structured assemblies.

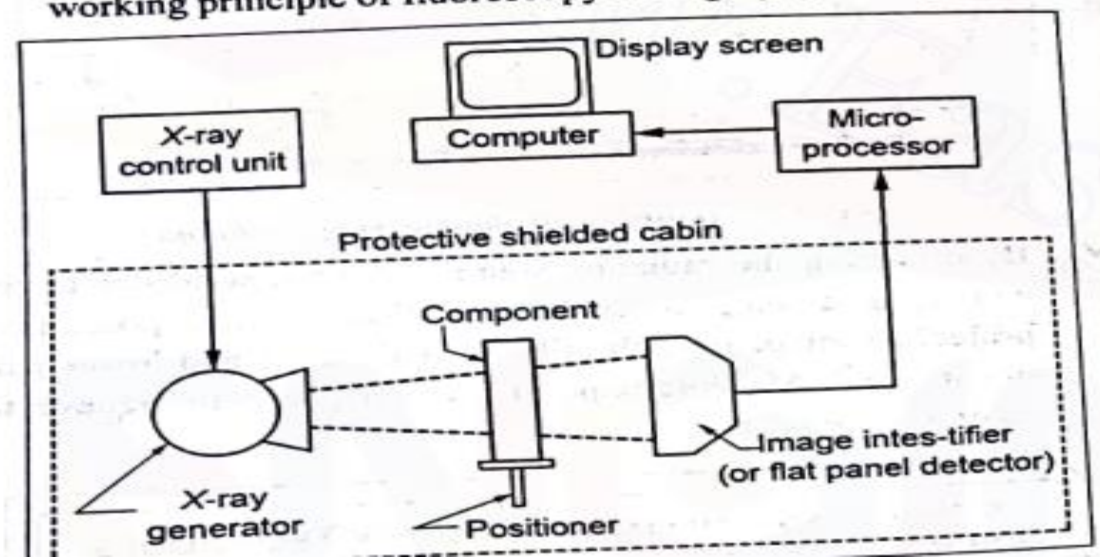
5.14. FLUOROSCOPY (RADIOSCOPY) TESTING

5.14.1. What is Fluoroscopy?

- ✓ *Fluoroscopy, also known as radioscopy, is a technique whereby "real time" detection of defects is achieved by the use of specialized fluorescent screen technology.*
- ✓ In this testing method, image of the defects in the component is produced by ionizing radiation on a radiation detector such as a fluorescent screen or an array of solid state sensors which is then displayed on a computer or television screen.
- ✓ These radiography systems work in real time and can provide continuous inspection of objects, hence it is also called as ***"Real Time Radiography (RTR)"***.

5.14.2. Arrangement and Working Principle

- ✓ Fig. 5.30 shows the arrangement of equipment and the working principle of fluoroscopy radiography testing.



- ✓ *In fluoroscopy testing, the film is replaced by a fluorescent screen then the image of the test piece can be visually seen.*
- ✓ *Image intensifier or flat panel detector is used to covert ionized radiation into images.* The image intensifier commonly used as a converter device, contains a fluorescent material such as ceisium iodide.
- ✓ The *X*-rays are passing through the object excite the fluorescent material producing bright spots in the more heavily irradiated areas. These photons are converted to electrons, accelerated and reconverted into light on the output screen.
- ✓ Flat panel detectors contains an array of sensors provide various pixel sizes with extensive image dynamics. Since the signals received are digital, the screen image can be optimized for interpretation.

5.14.3. Advantages of Fluoroscopy Testing

Some of the advantages of fluoroscopy testing are as follows:

(i) Immediate viewing of the objects for defects.

(ii) Ability to study moving parts in action.

(iii) Less expensive on film and film processing cost.

(iv) Possibilities of comparing obtained image with a reference image for defect interpretation.

5.14.4. Limitations of Fluoroscopy Testing

Some of the limitations of fluoroscopy testing are as follows:

(i) Initial cost of equipment is very high.

(ii) Not portable as in gamma ray testing.

(iii) Special cabinet is required to keep exposure to radiation within regulations.

5.14.5. Applications of Fluoroscopy Testing

Fluoroscopy radiography testing is widely used for the inspection of:

(i) thin wall section castings;

(ii) welded assemblies;

(iii) coarse sandwich constructions;

(iv) plastic parts are checked for the presence of metal particles or cavities; and

(v) electric equipment such as switches, capacitors and radio tubes.

1.10 ULTRSONIC TESTING METHODS

There are three methods used in ultrasonic testing. They are,

i. Pulse echo method

ii. Through transmission, and

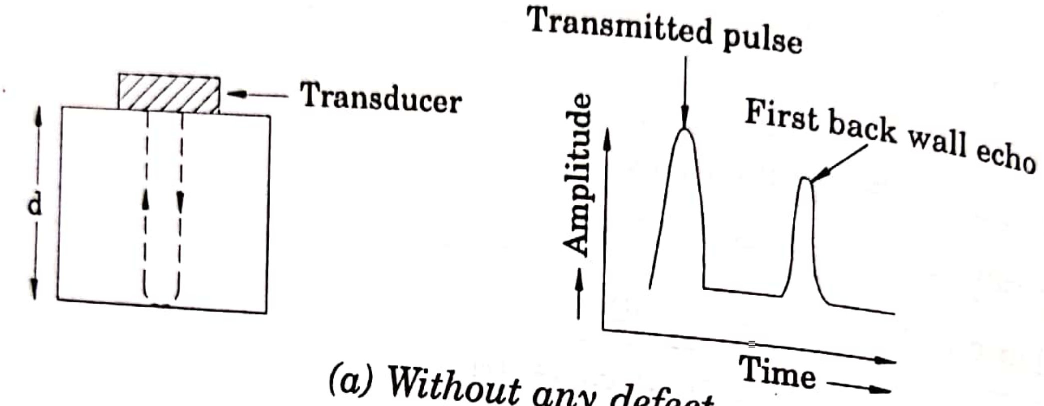
iii. Resonance method

In pulse echo method, the reflected ultrasonic waves are used to identify and characterize the flaw. In through transmission method, the transmitted beam will be used to identify and characterize the flaw. The above three methods are normally employed in industries for ultrasonic testing.

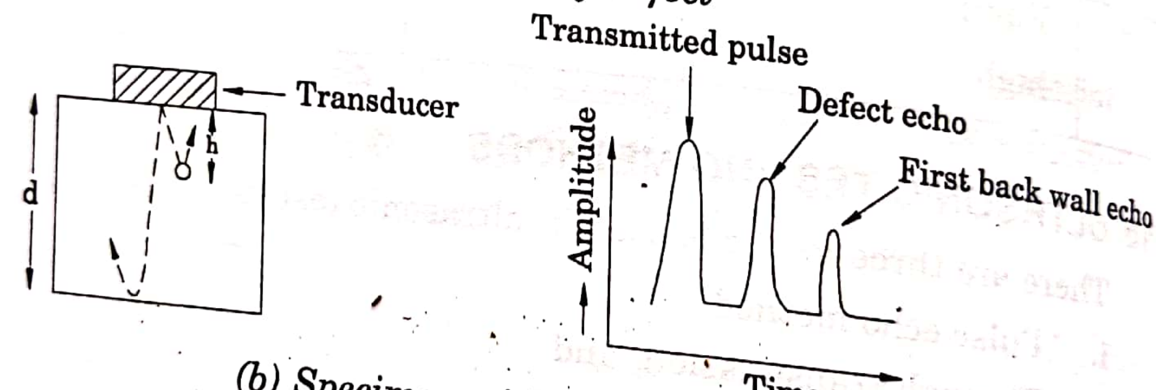
(i). Pulse echo (PE) method

Pulse echo method is the most popular and commonly used method. In this method, a single probe is used for the transmission and reception of the ultrasonic signal. The working of pulse echo method is as shown in Fig.(1.21).

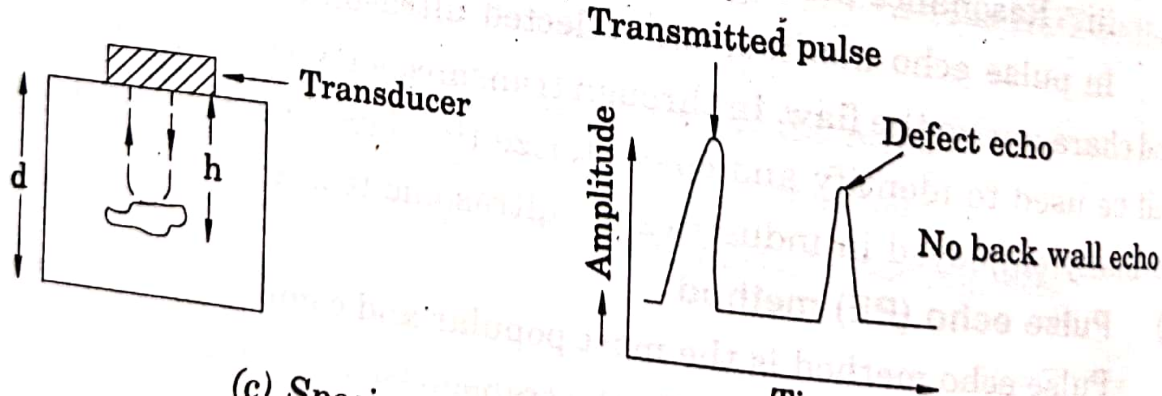
For the purpose of identifying the defects in the specimen, the CRT screen is first calibrated between the transmitted pulse and the time of arrival of the first back wall echo. When there is no defect in the specimen, the transmitted and back wall echo will appear as shown in Fig.(1.21 a). If there is any defect at a depth 'h' from the top surface of the specimen, a part of the ultrasonic wave gets reflected from the defect and a part at the back of the specimen. The time domain traces obtained in this case is as shown in Fig.(1.21 b). The reflected signals from the defect appear in between the transmitted pulse and back wall echo. By measuring the distance of the defect echo from the initial pulse, the depth of the defect is determined. When the defect is larger, the entire signal is reflected by the defect and hence there is no back wall echo. The observed time domain traces is as shown in Fig.(1.21 c).



(a) Without any defect



(b) Specimen with small defect

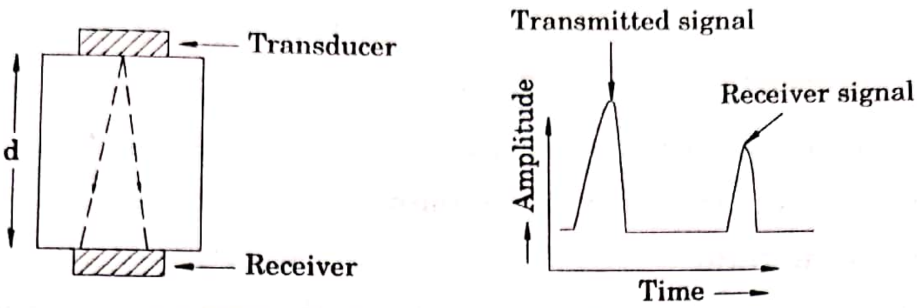


(c) Specimen with larger defect

Fig.1.21 Principle of pulse echo method

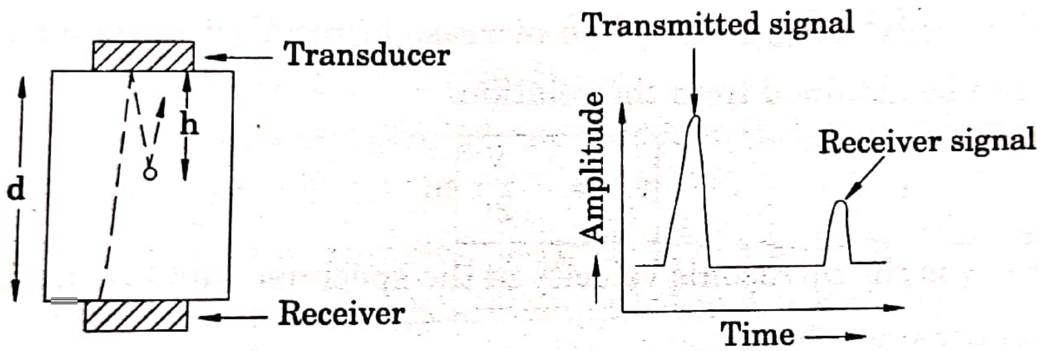
(ii). Through transmission method

This method consists of two probes. The first probe generates the ultrasonic signals and is known as transducer. The second probe receives the signal and is known as receiver. The positions of the transmitter and receiver probes are as shown in Fig.(1.22). Let 'd' be the thickness of the material. Consider a defect in the material, at a depth of 'h' from the top surfaces.



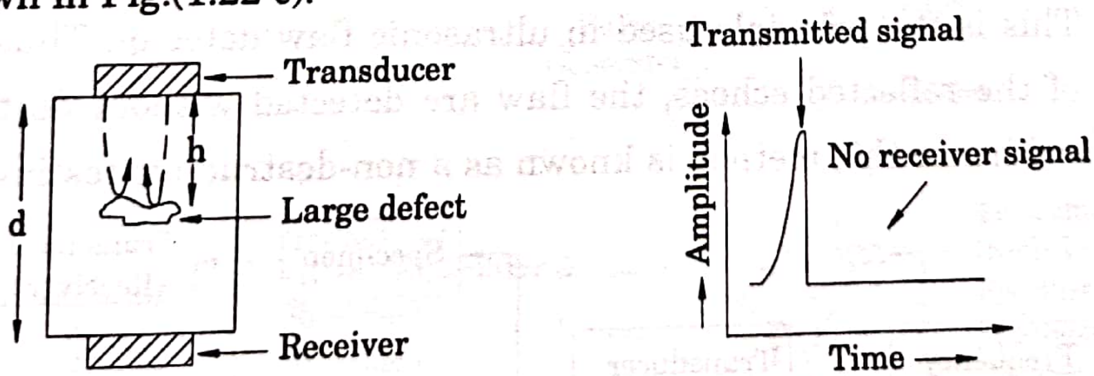
(a) Without any defect in the specimen

When there is no defect in the specimen, the time domain trace obtained in the CRT is as shown in Fig.(1.22 a). If there is any defect at a depth 'h', the time domain trace obtained is as shown in Fig.(1.22 b). the amplitude of second signal reflects the nature of the defect.



(b) Specimen with small defect

When the ultrasonic waves are completely reflected by the defect, the transmitted signal is completely lost. In this case the defect is large. Therefore, the receiver does not receive any signal and the corresponding time domain trace is as shown in Fig.(1.22 c).



(c) With large defect in the specimen

Fig. 1.22 Principle of through transmission method

1.11. ULTRASONIC FLAW DETECTOR

Principle

Ultrasonic waves travels in different medium with different velocities. *Whenever there is a change in the medium, then the ultrasonic waves will be reflected.* This is the principle used in ultrasonic flaw detector. Thus, from the intensity of the reflected echoes, the flaw are detected without destroying the material and hence this method is known as a non-destructive testing method.

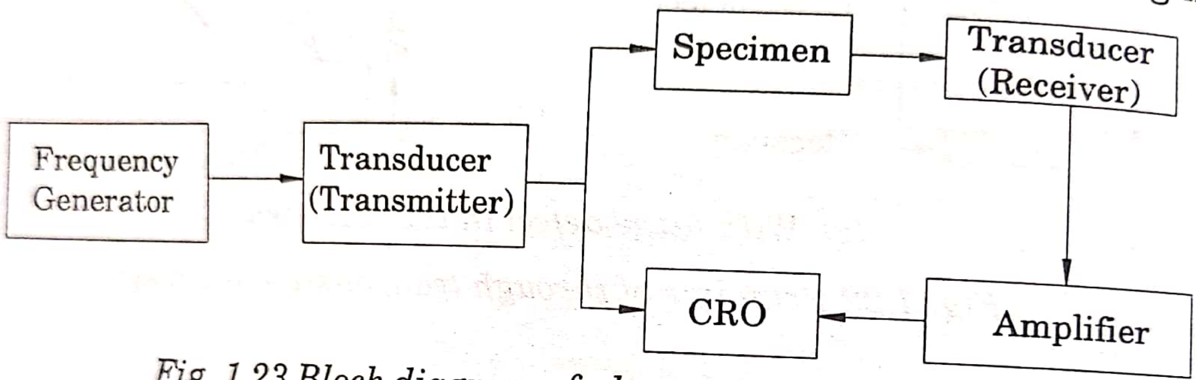


Fig. 1.23 Block diagram of ultrasonic flaw detector

Description

It consists of a piezo electric transducer coupled to the upper surface of the specimen (metal) without air gap between the specimen and the transducer. A frequency generator is connected to the transducer to generate high frequency pulses. The total set up is connected to the amplifier and to a cathode ray oscilloscope as shown in block diagram Fig.(1.23).

Note : *A transducer is a device which converts a non electrical signal to an electrical signal and vice-versa. For example, Piezo crystal can be used both for generating and detecting the Ultrasonic waves.*

Working

i. The pulse generator generates a high potential difference and is applied to the piezo electric transducer.

ii. The piezo electric crystals are resonated to produce ultrasonic waves.

iii. These ultrasonic waves (pulse) are recorded in CRO and is transmitted through the specimen

iv. These waves travel through the specimen (metal) and is reflected back by the other end.

v. The reflected ultrasonics (pulse B) are received by the transducer.

vi. These reflected signals are amplified and if it is found to be almost the same as that of the transmitted signals as shown in Fig.(1.24 a) then there is no defect in the specimen.

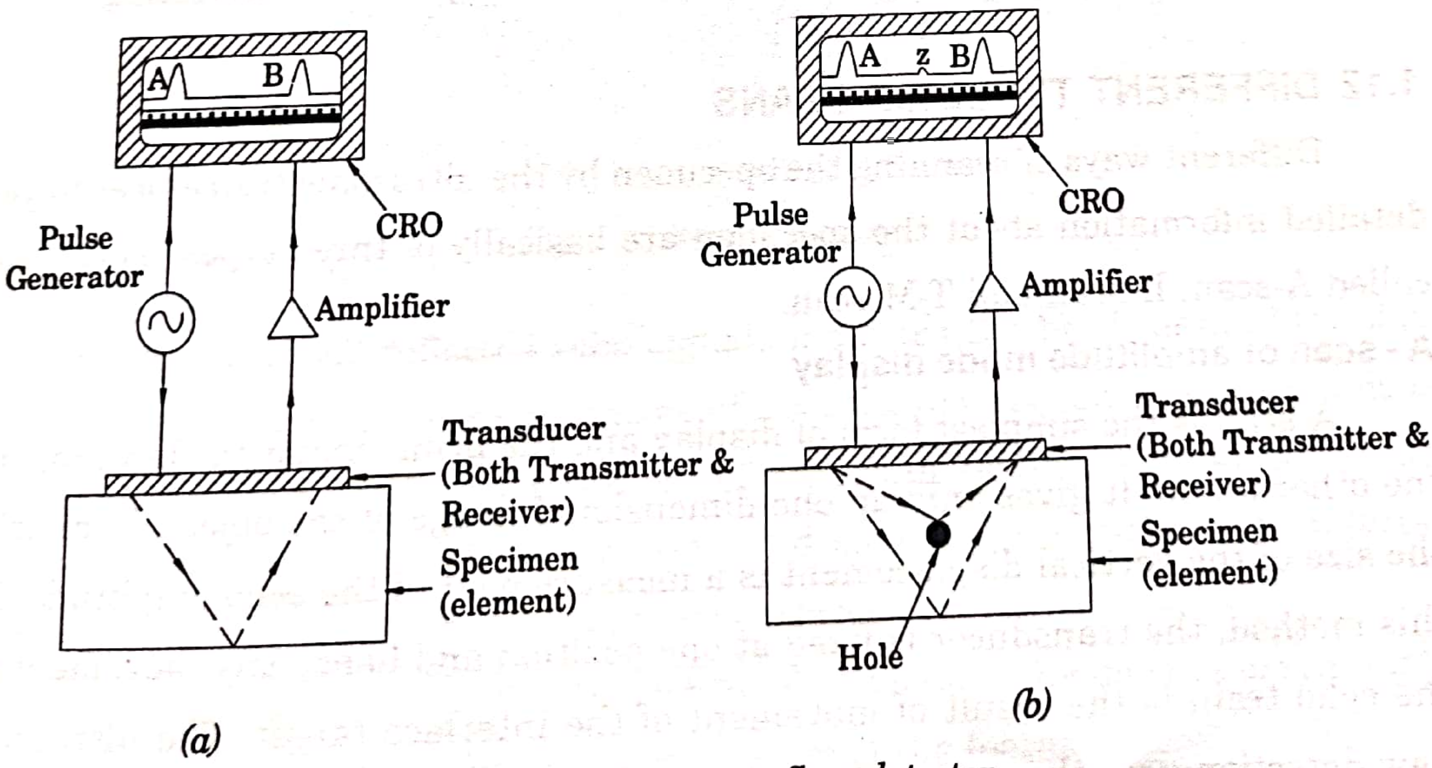


Fig. 1.24 Ultrasonic flaw detector

(iii). Resonance method

Generally, in any materials one can obtain the resonance condition when the thickness of the material is equal to half of the wave length of sound or any multiple there of. The wavelength of the ultrasonic wave depends on the frequency. Therefore, one can create the condition of resonance for the thickness of the plate under test by varying the frequency of the ultrasonic waves. The condition of resonance is easily recognised by the increase of received pulse amplitude. The thickness can be obtained from the relation.

$$\boxed{t = \frac{v}{2f}}\ m$$

where, v is the ultrasonic velocity in the specimen and f is the fundamental frequency of the resonance.

RADIOGRAPHIC TESTING

- Radiography is used in a very wide range of applications including medicine, engineering, security, etc.
- In NDT, radiography is one of the most important and widely used methods.
- Radiographic testing (RT) offers a number of advantages over other NDT methods, however, one of its major disadvantages is the health risk associated with the radiation.
- In general, RT is method of inspecting materials for hidden flaws by using the ability of short wavelength electromagnetic radiation (high energy photons) to penetrate various materials.

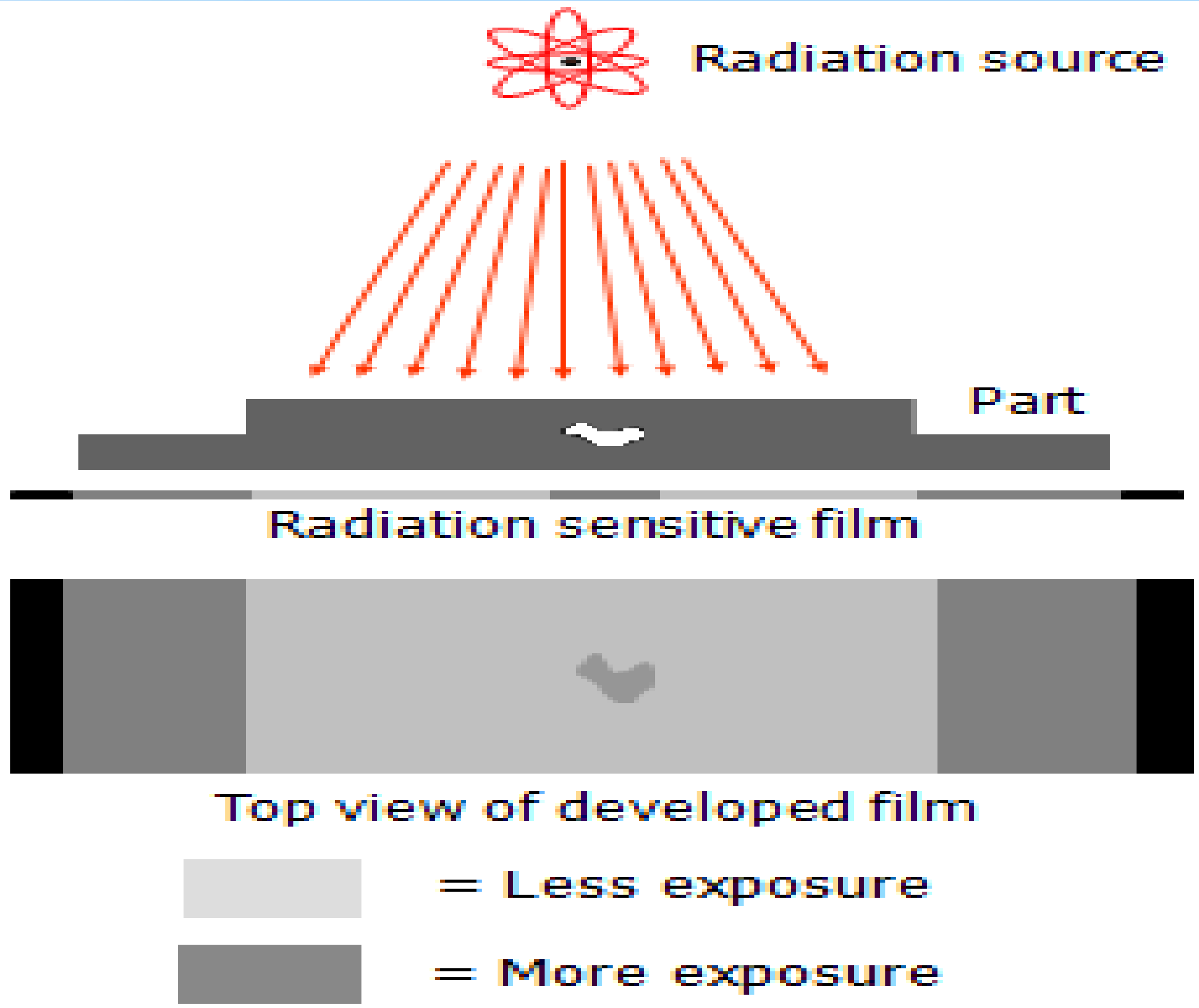
* Radiographic Testing

- In radiographic testing, the part to be inspected is placed between the radiation source and a piece of radiation sensitive film.
- The radiation source can either be an X ray machine or a radioactive source The part will stop some of the radiation where thicker and more dense areas will stop more of the radiation.
- The film darkness (*density*) will vary with the amount of radiation reaching the film through the test object where darker areas indicate more exposure (*higher radiation intensity*) and liter areas indicate less exposure (*higher radiation intensity*).
- This variation in the image darkness can be used to determine thickness or composition of material and would also reveal the presence of any flaws or discontinuities inside the material.

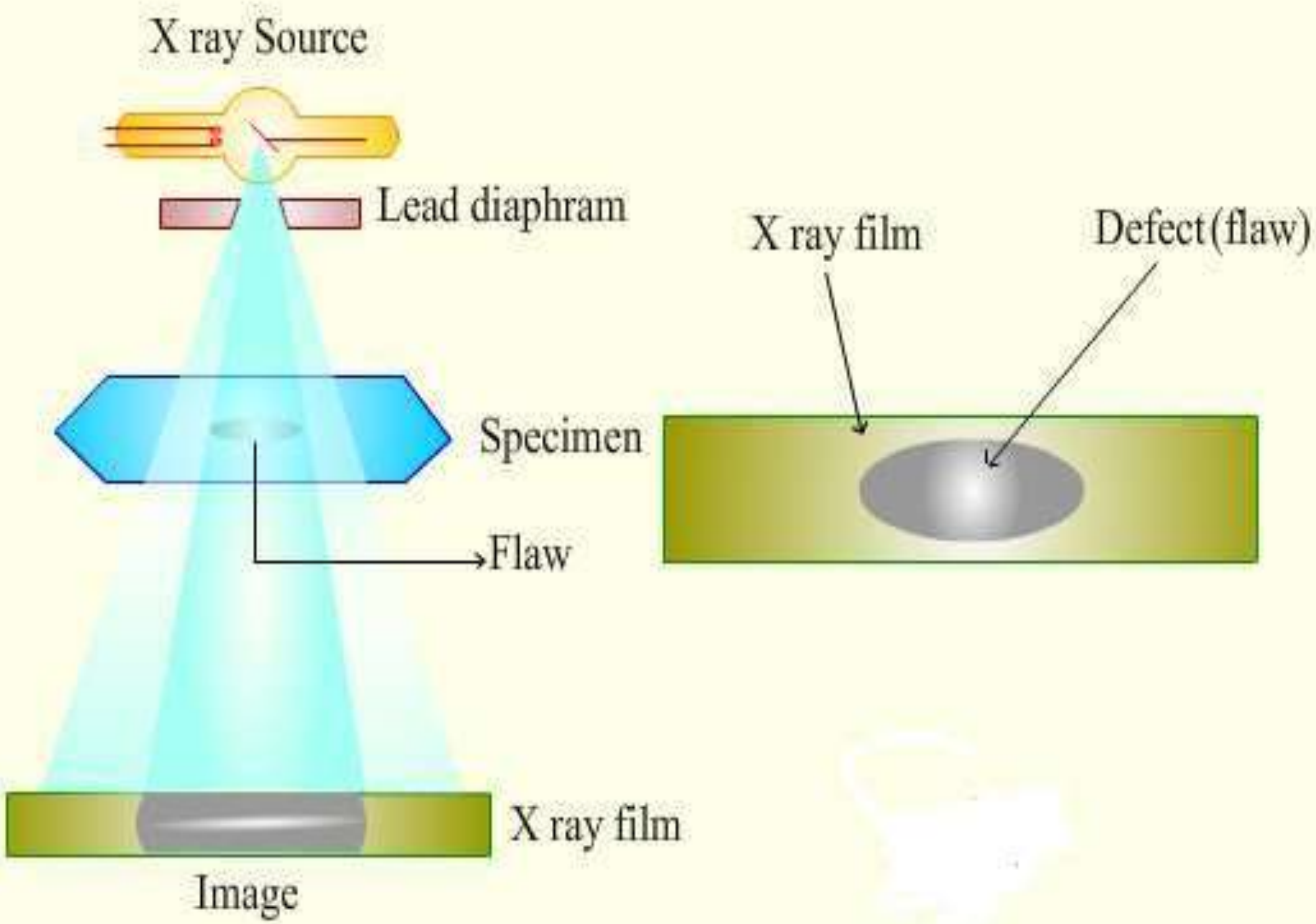
*

Basic Principle

- X-rays are passed through the specimen under inspection and it is differentially absorbed by the specimen.
- The transmitted x-rays are received by the photographic film and the film is developed.
- The dark and light shadows reveal the defects present in the specimen


Radiation source
Part
Radiation sensitive film
Top view of developed film
= Less exposure
= More exposure

X - RAY RADIOGRAPHY



Advantages

- Both surface and internal discontinuities can be detected.
- Significant variations in composition can be detected.
- It has a very few material limitations.
- Very minimal or no part preparation is required.
- Permanent test record is obtain

*

*Disadvantages

- High degree of skill and experience is required for exposure and interpretation.
- The equipment is relatively expensive (*especially for x-ray sources*).
- The process is generally slow.
- Highly directional (*sensitive to flaw orientation*).
- Depth of discontinuity is not indicated.
- It requires a two-sided access to the component.

- X-ray Radiation
- Gamma Rays Radiation
- Neutron Radiation

Types Of Radiation